VOLUME 14, NO. 3
MARCH 1982

THE SHOCK AND VIBRATION DIGEST

A PUBLICATION OF
THE SHOCK AND VIBRATION
INFORMATION CENTER
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

OFFICE OF
THE UNDER
SECRETARY
OF DEFENSE
FOR RESEARCH
AND
ENGINEERING

THE SHOCK AND VIBRATION DIGEST

Volume 14, No. 3
March 1982

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SVIC NOTES

THE SHOCK AND VIBRATION BULLETIN REVIEW PROCESS

The process of reviewing contributed papers for publication in the 52nd Shock and Vibration Bulletin has been completed and I would like to thank all who participated this year and in the past years. As usual, this year the reviewers recommended that a high percentage of the contributed papers should be published.

Since the 43rd Shock and Vibration Symposium, we have required all authors who want to publish their papers in the Shock and Vibration Bulletin to submit a draft manuscript to be examined by two qualified reviewers. The reviewers are asked to recommend whether the paper should be published "as is," published with changes or not published at all. If the reviewer recommends a paper should be published with changes, we send their comments to the author who is then free to decide whether to modify the paper. I believe most authors do make the recommended changes even though publication of their papers in the Shock and Vibration Bulletin is rarely contingent on doing this. Furthermore, I believe most authors welcome paper reviews because they are glad to have an independent evaluation of their peers who may be in a position to recommend changes that will improve the quality of their papers.

We send the reviewers a set of general guidelines that may help them to evaluate a paper's technical content. We do not attempt to set absolute criteria for publication of a paper because of the wide range of interests in our shock and vibration technical community. In effect, we ask the reviewers to decide whether publishing a paper will contribute to the advancement of the state of technical knowledge in our field. This is a difficult question to resolve, since advancing the state of technology is not limited to disclosing new developments or new concepts. Consider these examples. A paper might be published that helps to explain poorly understood concepts. Another paper might be published that would help to settle a controversial technical issue. Yet still another paper might contain a critical review of some aspect of shock and vibration technology. Each of the above contributes to the state of our technical knowledge, yet does not represent new developments or concepts.

The reviewers will inevitably find a few papers that are so seriously deficient that they should not be published. There are a number of reasons why papers are rejected. The three most common are that the paper is not clearly written, that the paper contains information that is readily available elsewhere, or that a paper contains information that is technically incorrect. With the possible exception of the last reason, the reviewers would rarely recommend that a paper not be published for any single reason.

Our review process has changed very little over the last few years and, although it is not perfect, it has worked well. We are anxious to receive suggestions for improving our review procedure.

R.H.V.

EDITORS RATTLE SPACE

THE MAGIC OF THE CALCULATOR

I was at a recent demonstration of a device to align machinery in its working environment and am, as a result, motivated to reflect on the role of small calculators in performing standard engineering techniques. The key element in the alignment device was a small programmable calculator. It was specifically dedicated to perform a task usually done graphically. Each year many such routine techniques done by engineers could be programmed on one of the many programmable calculators available.

Some programs have been formalized and widely distributed. In fact, Hewlett-Packard (HP) maintains a clearing house for new programs and programming techniques in their newsletter. Other programs have been generated by engineers but are not documented or distributed. It would be worthwhile to have many of these programs documented and available for others to use.

The vector method for two-plane balancing and the Holzer method for torsional natural frequencies are good example of techniques that have been programmed on small calculators. Recently, in fact, a short paper was written and published on the use of the TI calculator for balancing rotors. This comprehensive paper, by Bill Fagerstrom of E.I. DuPont de Nemours, contained descriptions of five basic balancing programs that had been programmed on the TI 59 calculator. Charlie Jackson at Monsanto has programmed and documented single-plane, two-plane, and vector-splitting techniques for rotor balancing on the HP 67/97 calculator. This work has been published and is widely used. In the area of torsional vibrations, Harold Hershkowitz of Scientific-Atlanta has programmed and documented the Holzer method for natural frequency calculation for both the HP 67/97 and TI 59 calculators.

These men and others are to be commended for their efforts in making techniques available to engineers and technicians. As a result of their work, other engineers need not waste effort in personally programming these techniques and many hours can thus be saved because the techniques need not be repeated by hand. The programmable calculator not only saves much time on routine tasks but also allows many persons access to and use of techniques that they would usually not have used. I hope that these factors will motivate others to document and publish their programs for general use by engineers.

R.L.E.

RANDOM WAVES IN SOLID MEDIA

A.I. Beltzer*

Abstract. This is the first survey of recent developments in a new topic of solid dynamics: propagation of random waves in regular (nonrandom) solid media. Basic problems are formulated and results obtained. Applications in the mechanics of composite materials, acoustic emission, and earthquake engineering are discussed.

It has recently been recognized by investigators in the area of solid dynamics that the propagation of waves random in time through regular (nonrandom) media is of interest. The necessity to investigate this phenomenon arises from the considerable uncertainty inherent in physical situations involving propagating disturbances. This uncertainty can be caused by a physical mechanism itself as well as by a lack of information. Examples are disturbances due to an earthquake or to evolution of material imperfections.

Random wave propagation has two physical aspects: a source and a solid waveguide (a solid medium). The source behavior is assumed to be stochastic or incompletely known; the waveguide is taken to have a regular structure. Random waves emitted by the source can be subjected to spectral filtering and attenuation as they travel in a medium. This phenomenon is referred to as the evolution of waves. Diffraction of the waves also occurs if the medium is not homogeneous. The analysis of random waves in solid media thus includes the following stages: radiation, evolution, and diffraction.

RADIATION

Haskell [1] and Aki [2] considered the radiation of elastic waves due to randomly propagating faults from the geophysical viewpoint. Haskell [1] used the autocorrelation function of the slip acceleration and Aki [2] used the autocorrelation function of the slip velocity to describe the source behavior. In both cases the autocorrelation function depends upon two parameters. Some assumptions and simplifications regarding statistical characteristics of the fault motion were necessary to obtain the numerical results.

Waves due to randomly moving dislocations are of interest for the analysis of acoustic emission in engineering materials. Beltzer [3] considered transient waves produced by the random motion of a screw dislocation. He used the process of shot noise type to model the dislocation motion. The duration and rate of the dislocation movement were shown to affect the parameters of the emitted waves.

A key difficulty of work on radiation of random waves has been a lack of information on the actual behavior of the source. Adequate modeling will be possible only when the near-field response of moving faults or dislocations has been experimentally investigated in greater detail.

The concept of diffuse waves, which is used in room acoustics, was applied to solid media by Egle [4]. Space and time averages of the kinetic and potential energy densities play a central role in the analysis of the wave field, which is taken to be a superposition of plane harmonic body waves. The results obtained can be applied only in situations for which nonhomogeneous or surfaces waves can be neglected.

Applications of the concept of randomly propagating disturbances to practical problems of acoustic emission can be found in the works of Lucia and Redondi [5] and Egle [6]. It should be noted that acoustic emission analyses provide one of the most promising applications for the theory of random waves. The considerable uncertainty concerning a source behavior in any practical case of acoustic emission makes use of the stochastic approach inevitable.

*School of Aerospace, Mechanical and Nuclear Engineering, University of Oklahoma, 865 Asp Avenue, Room 212, Norman, Oklahoma 73019

EVOLUTION

Because of attenuation and dispersion effects the statistics of random waves depend on the observation point. Saichev [7] considered the evolution of one-dimensional geometrically nonlinear random waves in a Hookean medium. He used the relation between the Lagrange and Euler formulations. This work is an outgrowth of his previous investigations of random optical waves.

Results on evolution of random viscoelastic waves (body as well as surface) have been obtained by Beltzer [8, 9]. In one case [8] an infinite isotropic viscoelastic medium was defined by two complex wavenumbers $k_i(\omega)$; i = d for a dilatational wave, and i = s for a shear wave. Derivation of the equation of evolution for plane waves requires the assumption that stationary waves emanate from a plane, say $z = -z_0$ ($z_0 > 0$), which vibrates with a complex random amplitude $A(\omega, -z_0)$. The wave of displacement $w_i(t, z)$ can be written in the form of stochastic integrals representing a superposition of waves with random phases and amplitudes

$$w_i(t,z) = \int_{-\infty}^{\infty} e^{-i\omega t} e^{ik_i(\omega)\bar{z}} dA(\omega_1, -z_0) = \int_{-\infty}^{\infty} e^{-i\omega t} dA(\omega, z) \qquad (1)$$

where i = d,s and $\bar{z} = z + z_0$. From equation (1) the evolution of random amplitudes during travel is given by

$$A(\omega, z) = \int_{-\infty}^{\omega} e^{ik_i(\epsilon)\bar{z}} dA(\epsilon, -z_0) \qquad (2)$$

The spectra evolution are given by

$$S(\omega, z)/S(\omega, -z_0) = e^{-2\mathrm{Im}[k_i(\omega)]} \qquad (3)$$

Thus, only the imaginary part of the complex wave number affects the spectral density when a stationary process is considered. The evolution spectrum for the case of nonstationary random waves is obtained [8] as an extension of equation (3)

$$S(\omega_1, \omega_2, z)/S(\omega_1, \omega_2, -z_0) = e^{ik_i(\omega)\bar{z}} e^{[ik_i(\omega)]^* \bar{z}} \qquad (4)$$

The asterisk designates the complex conjugate.

The equations that govern the evolution of random surface waves propagating in a viscoelastic half-space have been obtained by Beltzer [9]. He showed that random surface waves are sensitive to the type of internal friction and to the distance between a source and an observation point. Figure 1 shows results for the case of random viscoelastic Rayleigh waves. The variance of the horizontal displacement at an external surface u_x is shown under the assumption that u_x at the origin x = z = 0 is a band-limited white noise with the spectrum

$$S(\omega) = \text{const} \quad |\omega| < \bar{\omega}$$
$$S(\omega) = 0 \quad |\omega| > \bar{\omega} \qquad (5)$$

In Figure 1 ν is the Poisson ratio and $k_s(\omega)$ is the shear wave number. Figure 1 represents a typical result of the evolution of random surface waves in viscoelastic solids. Statistical characteristics of elastic waves in rocks at high pressures have been investigated [10].

Random disturbances propagating in a solid medium are affected by the properties of the medium and thus contain useful information on the behavior of the material. It is believed that his phenomenon can be exploited as a means for identifying dynamic properties of engineering materials.

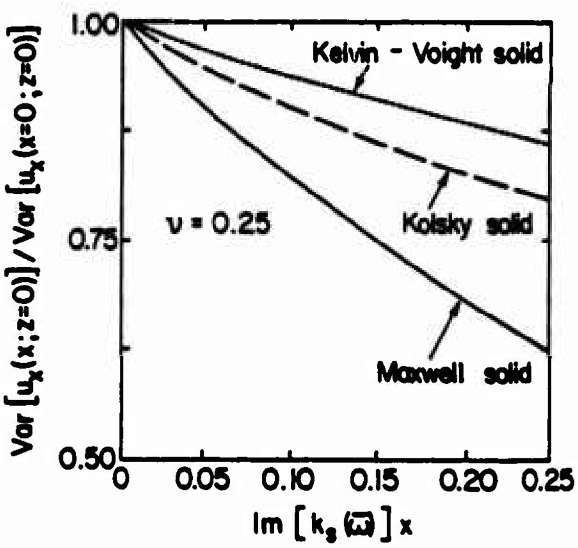

Figure 1. Variance of the Displacement u_x for Different Viscoelastic Models [9]

DIFFRACTION

Availabl‹ lutions to the diffraction problem are concerned ith an embedded rigid inclusion or with a Griffith crack. An elastic matrix containing a rigid sphere that is subjected to random waves can be viewed as an extension of a classical mechanical system consisting of a spring and a mass under stochastic excitation. Beltzer [11] obtained exact results for the response of a rigid embedded sphere. The simplicity of the derived equations that describe the motion of the sphere is worthy of note. Figure 2 shows the variance of the displacement W_p of the sphere under the random P-waves of the white noise type with a spectral density S_1. The effects of the Poisson ratio and the ratio between mass density of the inclusion and the matrix are explicit. The other relevant parameter is the ratio $a/C_p = \tau$; a is the radius of the sphere, and C_p is the dilatational wave velocity. Further treatment of this problem has been done for the case of an elastic matrix [12] and for a viscoelastic matrix [8].

Beltzer and Parnes [13] used numerical integration to study the multi-degree-of-freedom vibrations of a rigid embedded cylinder; the vibrations are induced by random P-waves of the white noise type.

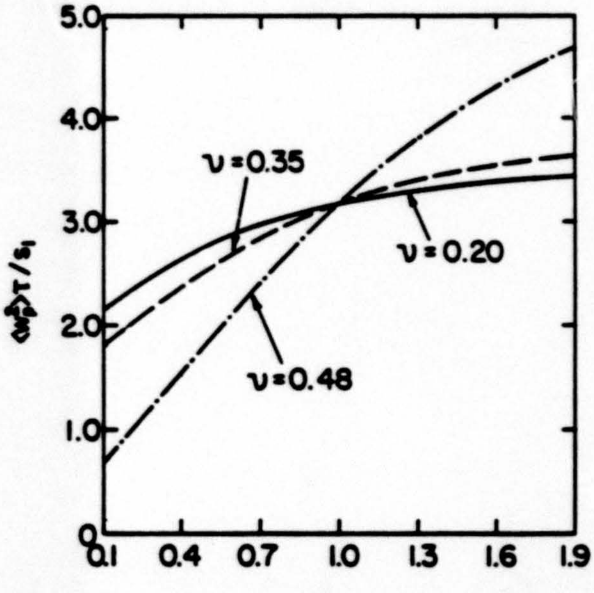

Figure 2. Mean-square Inclusion Displacement under White Noise Disturbance vs Density Ratio m [11]

Interesting phenomena are involved in the crack-random wave interaction. Beltzer [14] considered the effects of the distance between a crack and a source plane as well as energy loss on the response of the crack under random SH-waves. The response is markedly different when compared to a classical case of purely elastic deterministic incoming waves.

The stochastic formulation of wave-obstacle interaction problems should find many applications in the mechanics of composite materials. The effect of an inclusion on the matrix strength can be evaluated in terms of cumulative damage, and not only in terms of dynamic stress concentrations. The inclusion parameters can be chosen to amplify or depress the absorption of incoming waves or internal energy losses. Other applications involve the protection of buried structures subject to incompletely known or random disturbances. The approach makes it possible to account for the evolution of a random wave packet during its propagation and strike of a structure. The phenomenon of diffraction can be exploited as a means for monitoring random noises in solid media. This problem has been considered in Beltzer and Parnes [15].

CONCLUSION

Initial investigations of random wave propagation in solid media have provided a basis for understanding the key phenomena and illucidating several applications. However, fundamental problems remain unresolved. Response of composite materials to random propagation is of practical interest for synthesis of energy absorbing materials. Studies of radiation due to randomly moving imperfections can significantly improve our understanding of the acoustic emission mechanism. Analysis of nonlinear random waves in solids represents a challenge for the near future.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains articles about mechanical face seal dynamics and subsynchronous vibrations of rotor systems.

Mr. I. Etsion of the Department of Mechanical Engineering, Technion - Israel Institute of Technology, Haifa, Israel has written a review of mechanical face seal dynamics; experimental observations and theoretical analyses are summarized. The contribution of various elements of the seal to its dynamic behavior is discussed; the difficulties of analyzing seal dynamics are pointed out.

Mr. S.B. Malanoski of Mechanical Technology, Inc., Latham, New York has written an article reviewing literature published from 1979 through 1981, but especially in 1980, on subsynchronous vibration of rotor systems. Experimental and analytical studies cover various mechanisms for this instability that can be introduced by hydrodynamic bearings, high pressure fluid seals, labyrinth seals, and working fluids. Papers on practical experience for stability control are cited.

A REVIEW OF MECHANICAL FACE SEAL DYNAMICS

I. Etsion*

Abstract. A literature review of mechanical face seal dynamics is presented; experimental observations and theoretical analyses are summarized. The contribution of various elements of the seal to its dynamic behavior is discussed; the difficulties of analyzing seal dynamics are pointed out.

Mechanical face seals are used to seal fluids ranging from lubricants to highly toxic chemicals and acids. Applications range from helicopter transmissions to nuclear reactor cooling pumps and submarine propeller shafts. The function of these seals is to restrict leakage of the sealed fluid and to prevent the entry of solid and liquid debris.

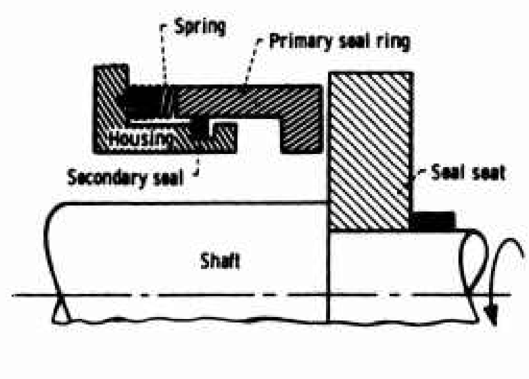
A seal permits a rotating shaft to penetrate an enclosure such as a transmission box, submarine hull, or pump housing while maintaining separation of the environments inside and outside the enclosure. One component of the seal is attached to the shaft and rotates with it; the other component is attached to the housing and is nonrotating. One of the components is flexibly mounted to provide angular and axial freedom of motion.

The Figure shows a mechanical face seal in which the seal seat is rigidly mounted to the shaft, and the seal ring is flexibly mounted to the housing. The flexible support consists of multiple springs equally spaced around the seal ring circumference and a secondary seal in the shape of an elastomeric ring such as an O ring. Other versions of flexible mounting exist [1].

Mechanical forces and fluid-film pressures should tend to force the flexibly mounted component into alignment with the rigidly mounted one. Relative sliding motion takes place between the faces of these two components. In order to avoid wear and to achieve long life the two sealing faces must be separated by a film of the sealed fluid. This film must be very thin to keep the leakage rate within acceptable limits. Thus, the requirements of lubrication and leakage tend to conflict.

In most mechanical seals currently in use where speeds and pressures are relatively low the separation between seal faces is only a fraction of one micrometer. Moreover, this separation is due mainly to surface macroroughness and is thus not complete; therefore, occasional contact between the stationary and rotating faces occurs. Such seals are termed contacting seals. As pressures and speeds in modern applications increase, any contact between seal faces should be avoided; the required separation between faces is of the order of a few micrometers. These seals are termed noncontacting seals.

Both contacting and noncontacting face seals can exhibit vibration of the flexibly mounted element. The nature of this vibration is important for safe operation of the seal. As mentioned above, the flexible support is intended for self-alignment between the seal faces. However, if the dynamic system is unstable, seal failure will occur because of uncontrolled vibrations.



Schematic of a Radial Face Seal

*Department of Mechanical Engineering, Technion - Israel Institute of Technology, Haifa 32000, Israel

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The review is divided into three sections:

- Papers related to experimental observations of seal vibration
- Papers related to investigations of dynamic properties of seals elements
- Papers related to theoretical dynamic analyses of mechanical face seals

Evidence of dynamic problems in mechanical face seals has been accumulating for almost two decades. However, this complex problem has not received much attention until recently. The number of theoretical papers treating the problem is small but constantly increasing. The field of mechanical face seal dynamics is far from exhausted.

EXPERIMENTAL OBSERVATION OF SEAL VIBRATION

Some of the earliest experimental work on mechanical seals was described in a classical paper by Denny [2] in 1961. He was probably the first to measure a separation between the faces of a seal model. He used a capacitance method and showed a mean separation of up to 10 μm. A cyclic variation with an amplitude of about 0.25 μm was superimposed on the mean separation. The frequency of this variation was about twice the rotational frequency of the rotor. Denny's model allowed only an axial motion of one face; therefore, no angular vibration could be detected. In addition, the measuring method could not distinguish between local face separation changes due to face waviness and axial vibration.

Matt [3] in 1963 described both axial and angular vibrations. He reviewed various aspects of seals having metal bellows instead of elastomers and springs as their flexible support. The angular vibration was attributed to angular misalignment of the seal seat with respect to the shaft. He described the mode of angular vibration as "similar to a coin spinning on a table and as it settles, it is touching the table at one transgressing point."

Following these early papers experimental evidence on cyclic variation of face separation began to accumulate. Hudelson [4] used miniature accelerometers to observe the motion of metal bellows seals in a cryogenic liquid. He noticed dynamic instability and concluded that the predominate modes of motion under such conditions were torsional oscillation and rocking about a diameter. Hudelson attributed dynamic instability to phase change of the sealed fluid taking place in the interface between the seal ring and seal seat. Pape [5] used capacitive proximity probes to measure dynamic changes in seal face separation, and he, like Denny, found film thickness fluctuations at twice the shaft rotational frequency. Pape concluded that these fluctuations are due only to macroroughness or waviness of the rotating face and that neither wobbling nor bouncing of the faces could produce the signal observed. However, the measuring system used by Pape could not detect absolute motion of the flexibly mounted element.

Strom, Ludwig, and Hudelson [6] observed the effect of damping on the vibration of a metal bellows seal. Lohou and Godet [7] measured axial vibration of a tilted seal model. Kaneta, Fukahori, and Hirano [8] observed and measured vibrations of four different types in a seal model. The basic mode of vibration was a wobble at the same frequency of shaft rotation. Etsion and Burton [9] measured wobble of a gimbal-mounted seal model and showed that half frequency wobble sometimes occurred. Metcalf [10] experimented with a noncontacting coned face seal. He found that three modes of operation exist: a stable mode characterized by wobble at the frequency of the shaft rotation; a transition mode in which half frequency wobble is superimposed on the previous basic mode; and an unstable mode with uncontrolled vibration.

DYNAMIC PROPERTIES OF THE SEAL ELEMENTS

The flexibly mounted ring of a mechanical face seal is affected by both the flexible support and the fluid film separating it from the rigidly mounted seat. Hence, the dynamic properties of both the flexible support and the fluid film play an important role in seal dynamics.

Fluid film effects. Following Denny's observations [2] much work was aimed at better understanding the operational mechanism of mechanical face seals. Most of this work dealt with fluid-film pressure generation mechanisms that would allow separation

of the seal faces. Fluid-film pressure depends, among other factors, on the shape and magnitude of the clearance between mating faces. Hydrodynamic and hydrostatic effects control the pressure in the fluid film and, thus, the forces and moments exerted by it on the seal ring. Early work dealt with steady-state calculation of these forces and moments. However, because the results depend on the thickness of the fluid film, some information on fluid-film stiffness could be obtained.

Various mechanisms of pressure generation have been reviewed [11] for the period from 1961-1978. They include angular misalignment, face waviness, surface roughness, phase change, thermoelastic effects, and vibration.

Some of the more recent work on fluid-film effects has been done by Hughes and Chao [12]. They showed that the fluid film can have negative axial stiffness due to phase change. Banergee and Burton [13] investigated thermoelastic effects that can cause face waviness. Lebeck [14] incorporated surface roughness and phase change effects with hydrostatic effects. Sharoni and Etsion [15] treated hydrodynamic effects in coned face seals having angular misalignment and showed a transverse moment acting at 90° out of phase from the tilt vector. Pothier and Rod [16] investigated pocket type seals, in which hydrostatic effects should predominate, and looked into tilt stability of such seals. Etsion [17] analyzed the effect of combined coning and face waviness, and Nau [18] summarized the history of mechanical face seal interface and calculated film cavitation boundaries.

Damping coefficients of the fluid film due to squeeze effects were analyzed by Lohou and Godet [7] for axial vibration with a constant tilt, and by Etsion [19] for both axial and angular vibrations.

Flexible support. The dynamic properties of the flexible support of mechanical face seals play an important role in the dynamic behavior of the seal ring. Unfortunately, very little research has been carried out so far. Some experimentation with metal bellows seal has been reported [6] in which viscous and friction damping added to the bellows affected seal vibration.

Rowles and Nau [20] estimated stiffness and damping coefficients of a typical seal support consisting of springs and elastomeric 0 rings. Their values can be regarded only as an order of magnitude and cannot be used for dynamic analyses. The reason is that the dynamic properties of elastomers are both frequency and amplitude dependent; this complicates the problem of seal dynamics. Some tests on the dynamic properties of elastomer 0 rings have been made with regard to dampers [21] and elastically supported gas bearings [22]. Kitmer and Metcalf [23] measured the forces exerted by elastomers on a reciprocating rod and applied it to mechanical seal. More recently Nau [24] reported on an investigation to study dynamic properties of elastomers. It appears that an increasing vibration frequency – which in face seals can result from increasing shaft speed – increases stiffness and reduces damping coefficients of the elastomeric ring.

As far as the author knows, no theoretical work has yet been published that would correlate dynamic properties of elastomers, 0 rings for example, with their mechanical properties and geometry. The few existing experimental results are but the beginning of the effort necessary to perform complete dynamic analyses of mechanical face seals.

THEORETICAL ANALYSES OF MECHANICAL SEALS DYNAMICS

Complete dynamic analyses cannot be performed without knowledge of the dynamic properties of elastomers. Indeed, all dynamic analyses published thus far are either incomplete or restricted to seals without any elastomers in their support.

The earliest dynamic analyses [25-27] neglected fluid-film effects altogether and dealt with contacting seals. Seal failure was considered when the mating faces lost contact. Both metal bellows and spring supported seals were investigated, and the equations of motion for one axial and two angular degrees of freedom were solved. Chaing and Cheng [28] analyzed the natural frequencies of large diameter seals, in which the elasticity of the seal ring plays an important role.

In noncontacting seals face separation is obtained and controlled by hydrostatic or hydrodynamic lift. It is important to keep the mating faces as parallel as possible; hence, good tracking ability of

seal runout by the flexibly mounted ring is required. Shapiro and Colsher [29] analyzed a jet engine gas seal in which face separation was maintained by small hydrodynamic gas bearings. These bearings provided stiffness and damping of the fluid film. The secondary seal consisted of a metallic rather than an elastomer ring. The damping provided by the support thus orginated from Coulomb friction. Kupperman [30] analyzed the tracking ability of noncontacting gas seals having spiral grooves to maintain face separation. Kupperman overlooked some of the fluid-film effects and neglected any damping of the seal support.

Hardt and Godet [31] analyzed axial vibration of a seal ring under a constant closure force but neglected ring inertia. Griskin [32] solved the equations of motion of a seal ring in its three major degrees of freedom. He incorporated in his analysis some constant damping coefficient of rubber secondary seal but neglected damping of the fluid film.

Ludwig and Gordon [33] investigated the response of the flexibly mounted ring to angular misalignment of the seal. They treated a liquid seal but, like Kupperman [30], overlooked various effects of the fluid film. Etsion and Dan [34] used small perturbation analysis to investigate noncontacting seal dynamics. They showed a critical operation speed below which the flexibly mounted element was stable. Above the critical speed any slight disturbance of the seal ring increased until contact occurred between the mating faces. Half-frequency wobble of the seal ring took place at the critical speed.

More recent analyses of tracking ability of the flexibly mounted seal ring have been done by Metcalf [35]. He incorporated 0 ring damping effects in his analysis and concluded that seal runout affects seal stability. However, Metcalf assumed some form of steady-state tracking and used approximated fluid-film effects. Etsion [36], who neglected damping of the flexible support and used small perturbation analysis, showed that runout is merely a forcing function and does not affect seal dynamic stability.

A complete dynamic analysis for a noncontacting coned-face seal without elastomers in its flexible support has been performed by Etsion [37]. He accounted for all fluid-film effects including cavitation and showed that three modes of operation exist, depending on various operation and design parameters. A seal can either be stable, be unstable, or operate at a transition mode in which half-frequency wobble occurs. Etsion and Auer [38] used computer graphics to demonstrate dynamic behavior of the seal in the three modes of operation.

Burton and Wu [39] made the first attempt to combine thermoelastic and hydrodynamic effects in a dynamic analysis. They concluded that face waviness is required for safe seal operation. Such waviness can be produced by the thermoelastic effect.

CONCLUSION

Seal vibration has been a problem for seal users, designers, and researchers for almost two decades. During this time most of the effort has been devoted to understanding the pressure generating mechanisms that cause face separation. This effort has resulted in valuable information on steady-state operation of mechanical face seals.

The dynamic behavior of mechanical face seals has only recently begun to receive attention. The problem is complex, and its solution requires knowledge of the behavior of thin fluid films as well as of the dynamic properties of elastomers. Early work on steady-state seal operation provided some information on the stiffness and damping coefficients of the fluid film. The flexible support contribution is, however, far from being well known. Some experimental work on elastomer 0 rings has been done recently, but the information on dynamic properties of elastomers is not yet complete.

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SUBSYNCHRONOUS VIBRATIONS OF ROTOR SYSTEMS

S.B. Malanoski*

Abstract. This article is a review of the literature published from 1979 through 1981, but especially in 1980, on subsynchronous vibration of rotor systems. Experimental and analytical studies cover various mechanisms for this instability that can be introduced by hydrodynamic bearings, high pressure fluid seals, labyrinth seals, and working fluids. Papers on practical experience for stability control are cited.

Published reviews [1-33] on the dynamic instability of rotors in high performance turbomachinery provide an excellent background on the subject of subsynchronous vibrations of rotor systems. Instability phenomena, including internal damping, dry friction, journal bearing (oil whip), fluid forces, ball bearings, universal joints, and asymmetric factors have been presented [31], as has a literature review [32]. Some of the more commonly recognized sources of instability have been described; a measure of the strength of each is given in the form of damping necessary to stabilize the rotor system [33]. Lund [33] concluded that, of the five sources of instability models described – shaft asymmetry, shaft internal viscous damping, shaft internal hysteretic damping, aerodynamically induced whirl, and hydrodynamically lubricated journal bearings – lubricated journal bearings are the strongest. It can thus be concluded that liquids provide the most benefits or problems, depending on how they act in a dynamic system.

In practice, the most commonly cited cases of subsynchronous vibration are in high-speed/high-powered density compressors and pumps. Sketches are shown in Figures 1 and 2; areas of important subsynchronous vibration are noted.

The areas of subsynchronous vibration covered in this review include bearings, fluid film seals, working fluid effects in labyrinths and stator-rotor interactions, friction damping, torsional-lateral interaction, parametric excitation and asymmetry, and interference rubs.

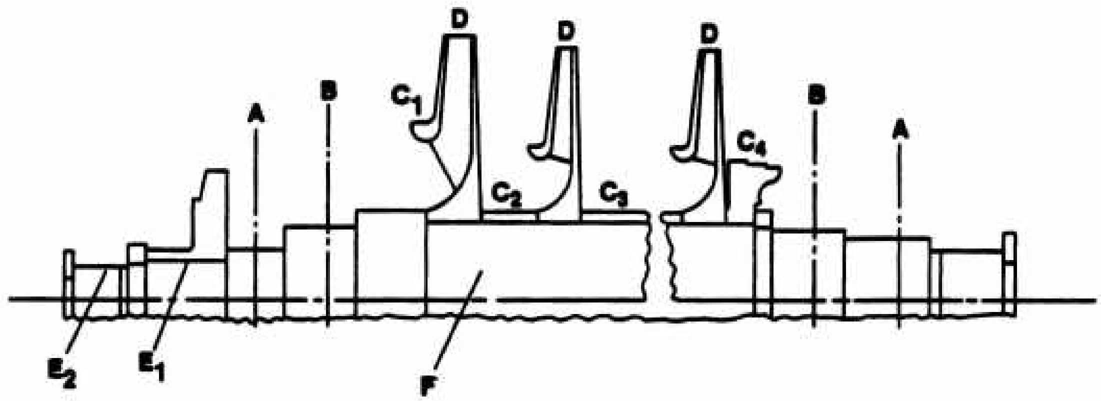
BEARING FORCES

Bearing forces have been studied on plain, fluid-film bearings, profiled fluid-film bearings, squeeze-film bearings, elastomers, and gas bearings. Basic papers on whirl in hydrodynamic bearings cover limit cycles [22], shaft instabilities observed experimentally [23], thermally induced whirl [34], remedial effects of damping [35], whirl interaction in pinion-gear systems [36], and oil whirl resonance [37]. Half-frequency whirl has been explained by a flow balance consideration in a bearing that loses its load capacity [38]. Rotor/bearing dynamic properties have been predicted using the finite element method [39].

Considerable analytical and experimental efforts have been put forth in the area of stability control with the use of fluid-film profiled bearings [27, 40-50]. Other methods of control involve the use of flexible-damped rotor supports in the form of squeeze films [28, 51-53] and elastomers [29, 54, 55]. An experimental comparison of the fluid squeeze-film damper and the elastomer damper has been made [55]. The effects of structural damping and external damping on stability have been studied [56, 57].

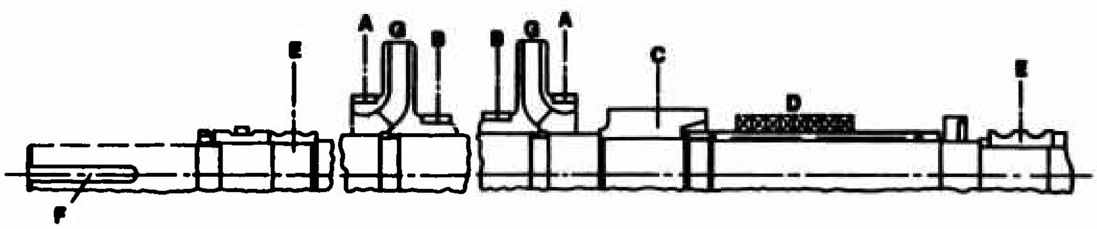
Gas-lubricated bearings and their influence on rotor/bearing dynamics and whirl instability have been covered [58, 59]. A multirotor, multibearing system has been examined with respect to misalignment and stability [60]. A vertical, canned motor pump stability and the effect of the support journal bearings have been examined [61]. A novel idea on active feedback control of dynamic instability of rotors has been presented [30].

*Mechanical Technology, Inc., 968 Albany-Shaker Road, Latham, New York 12110



A FLUID FILM BEARINGS
B BUFFER GAS/OIL SEALS
C_n LABYRINTH SEALS AT INLET, INTERSTAGE, CENTER SPAN, AND BALANCE PISTON
D WORKING FLUID: DIFFUSER/IMPELLER INTERACTION
E FRICTION DAMPING AT LONG SHRINK FIT, SPLINE COUPLING
F INTERNAL MATERIAL DAMPING AND ASYMMETRIC STIFFNESS PROPERTIES

Figure 1. Partial Cross Section of Multistage Gas Compressor



A NECK RING SEAL
B INTERSTAGE SEAL
C BALANCE PISTON SEAL
D PACKING GLANDS, OR BREAKDOWN BUSHINGS
E BALL BEARINGS (ASYMMETRY AND NONLINEARITY)
F FRICTION DAMPING AND/OR ASYMMETRIC STIFFNESS PROPERTIES
G WORKING FLUID: STATOR/IMPELLER INTERACTION

Figure 2. Cross Section of Multistage Liquid Pump (Partial Sections)

OTHER FORCES

Seal forces. Few papers have been published on the effect of fluid-film seals on stability and subsynchronous vibrations including buffered gas-oil seals, pump interstage seals, and labyrinths. The original paper [8], which is gradually becoming a classic, dates from 1965. However, considerable progress and outstanding contributions have been made in recent years concerning high pressure oil seals [62] and pump seals [10, 12, 14, 63]. A summary of pioneering work in fluid-filled clearance spaces in pumps has been given [64].

Analytical and experimental studies on the effects of labyrinth seals, including balance pistons, on the dynamic stability of rotors have been made [11, 13, 65, 66]. Control of destabilizing forces involving inlet swirl webs, or deflectors, has been suggested [13].

Work fluid forces. The need for more study in work fluid forces became apparent as a result of the development of high performance turbomachinery operating at high speeds and high energy-density levels. Significant practical experiences in the compressor area have been reported [1, 3-6, 9, 67]. Analytical studies directed toward the determination of impeller forces that can cause rotor instability have been made [16, 18, 19, 21]. A stability criterion has been given that relates the total fluid and rotor structure damping required per compressor stage [19]. Important analytical work has been done on the effect of fluid forces on rotor stability of centrifugal compressors and pumps [17], and significant experimental results has been reported on impulse and reaction type turbines [20]. The use of axial sheet strips to minimize swirl flow and improve stability has been suggested [13, 20]. A test program to measure cross-coupling forces in centrifugal pumps and compressors has been proposed [15, 24]. The stability of a hollow shaft partially filled with liquid has been studied [68, 69].

Internal shaft damping forces. An excellent paper provides a physical interpretation on internal rotating damping as a mechanism for rotor instability [25]. In this same area, but of more practical interest, friction damping should be considered at internal joints. Spline coupling-induced vibration has been studied [70].

Torsional-lateral interaction. Torsional-lateral interaction has been treated analytically [71] and experimentally verified in the field [2]. A machinery train with a gearbox should not have torsional mode natural frequencies and gear excitation frequencies coincident with the damped, lateral modes of the individual rotor/bearing systems [2]. The fundamental lateral modes are particularly important.

Parametric excitation, asymmetric elements. Parametric excitation is a classical form of rotor instability that has been reviewed [31-33]. More recent papers in this area cite practical experiences [26, 72]. A torsional vibration problem caused by parametric excitation has been reported [73].

GENERAL INFORMATION

An excellent study on nonlinear response of turbine rotors to interference rubs has been reported [74]. Other publications treat rotor subsynchronous vibration and instability in a more general way [7, 28, 75-81]. It has been pointed out that linear analysis techniques are acceptable for studying the majority of practical rotor dynamics problems [76]. Two major areas of importance in the stability area are fluid-film and turbo-flow (working fluid) excitation effects [3, 20, 33].

The application of the theory of vibrations of mechanical systems in the Soviet Union over the last 50 years has been summarized [82]. Component mode synthesis has been used to perform transient and stability analyses of rotor systems [83, 84]. This approach allows for significant reduction in the system model without loss of accuracy and should have advantages when nonlinear analysis is required. A review of nonlinear rotor dynamics analysis has been published [85]. A rotor/bearing dynamics system approach to solving nonlinear problems, such as blade loss induced vibration, has been suggested [86].

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BOOK REVIEWS

DAMPING APPLICATIONS FOR VIBRATION CONTROL

P.J. Torvik, Editor
ASME, New York, NY, AMD - Vol. 38
1980, 158 pages, $24.00

This book is a collection of ten review articles on damping and is a continuation of "Structural Damping" edited by J. Ruzicka and published by ASME in 1959. The book can be divided in four parts. It emphasizes the role of damping in the control of resonant vibrations.

The first part consists of an article by W. Trapp and G. Bowie that is a historical account of damping research. The second part deals with damping materials and mechanisms of damping and consists of five articles. D.I.G. Jones reviews viscoelastic materials for damping applications and presents various models to describe material behavior, including the effects of frequency, temperature, and strain. C.W. Bert discusses damping in fiber-reinforced composite materials; R. Plunkett reviews friction damping. E. Ungar treats the damping of panels due to ambient air, and P.J. Torvik discusses the analysis and design of constrained layer damping treatments.

The third part is concerned with measurement and simulation of damping. F.H. Chu and B.P. Wang describe various experimental techniques for determination of damping in materials and structures; T. Belytschko and W.L. Mindle consider the treatment of damping in transient finite element computations.

The fourth part contains two articles devoted to design applications. A.D. Nashif discusses applications of damping for nose control in a valve cover of a diesel engine. J.P. Henderson presents constrained layer applications to turbojets as a means for combatting high-cycle fatigue.

This volume is a valuable and unique reference book on the subject of damping, which has not received the attention it deserves during the last two decades. The book will certainly be an indispensable source of information for scientists and engineers of theoretical, practical, or design inclinations. Furthermore, the book will certainly stimulate further research work on damping by identifying various existing problems.

The articles in general cover, in a clear way, most of the relevant areas of damping and its applications. However, the emphasis is on linear viscoelasticity and harmonic vibrations. The reviewer feels that more attention should have been given to transient and nonlinear phenomena including modern theories of viscoplasticity. The reviewer also thinks that the historical review on damping progress and the constrained layered damping treatments articles are rather long and that the article on damping in transient computations could be expanded.

D. Beskos
Department of Civil and Mineral Engineering
University of Minnesota
221 Church Street S.E.
Minneapolis, Minnesota 55455

MECHANICS OF ELASTIC STRUCTURES

J.T. Oden and E.A. Ripperger
McGraw-Hill Book Co., New York, NY
1980, 2nd Edition, 460 pages, $27.95

The authors are distinguished faculty members at the University of Texas. The book is a second edition and is intended primarily as a text on intermediate strength of materials. The mathematical prerequisite is a course in ordinary differential equations (though Green's theorem and Fourier series also arise), and the underlying principles of structural mechanics are stressed, a welcome feature. With minor quibbles, I liked the book and would use it as a text. It is also a useful reference.

There are 10 chapters. A background discussion is given in Chapter 1. Chapter 2 opens with a treatment of stress components. This is not the strongest portion of the work. Beginning students could be confused by the absence of couples in the equilibrium discussions and by reference to X_s, Y_s, and Z_s as forces when they are forces per unit area. Further, defining the slanted face of the standard tetrahedral element as a boundary element detracts from the generality of the stress transformation laws. Stress resultants in bars are a major topic. With respect to Figure 2.8, the arguments that σ_y and σ_z are negligible could again puzzle a novice in that they do not arise in this section. The chapter closes with a brief treatment of Hooke's law for an isotropic solid and contains comments on stability. On page 30, $-\nu_x$ should be $-\nu\epsilon_x$.

Torsion of prismatic bars forms the material of Chapter 3. Circular bar results are given. Noncircular bars are analyzed using Prandtl's stress function and the membrane analogy. The solid ellipse is treated by an inverse method. A finite difference scheme is developed for other solid sections; specific application is to a rectangle. The strength of materials flavor of the work is evident in the comprehensive treatment of thin-walled open sections and single- and multi-cell thin-walled tubes.

Stress resultants in bars are taken up again in Chapter 4. A theory based on plane sections remaining plane and no twisting is developed for the normal stress-stress resultant relation for curved bars. Estimates are also given for radial stress. The theory is applied to the bending of curved planar bars; a circular bar with a rectangular cross section is treated in detail. Plane elasticity solutions for curved beams are obtained using Airy stress functions; comparisons are made with the technical theory. There appears to be an error on page 93: I could find no connection between equation (4.45) and the sentences immediately preceding it.

Shearing stresses and shear flow in bending are examined in Chapter 5. An integral equation for the shear stress in curved beams is found. From it an elementary theory is derived based on the assumption that the average values can be used. Plane stress solutions are obtained and compared with elementary ones. Poor agreement is found; iterative procedures are recommended. A section on variable depth, constant width beams is also given. The shear center is introduced; its location is found using shear flow concepts. Analyses of multi-flange-stringer structures and shear lag in thin-walled panels are given. The chapter ends with theories for bending, and bending and torsion, of straight, single-cell and multi-cell tubes.

Chapter 6 treats bar deflections. Force and moment deflection relations and appropriate boundary conditions are established. Applications are made to curved symmetrical bars and asymmetrical straight bars. Bernoulli-Euler theory is recovered as a limit, and integration methods for it are reviewed. It is curious that no use is made of the delta function for handling concentrated loads. Shear deformation effects are assessed for straight beams. Ties and beam columns, in which axial force effects cannot be neglected, are treated. The chapter closes with sections on cables and beams, beam columns, and ties on elastic foundations.

"Bending and twisting of thin-walled beams" is the title of Chapter 7. For beams with sections restrained against warping, St. Venant's principle can lead to significant errors, and stress distributions must be reassessed. A model for the deformation field based on the center of twist is developed. Strains, and from them stresses and stress resultants, are then calculated. The theory is still incomplete because the angle of twist and the bimoments (self-equilibrating stresses) are unknown. A determinate system is obtained after warping shear and associated shear flows are introduced. (I had trouble reading parts of this section. Such sentences as "The bimoment is statically zero and, in general, is a statically indeterminate quantity" slowed me down on several occasions.) Secondary warping is also discussed.

Chapter 8 treats the principles of virtual work. Virtual displacements of rigid and deformable bodies and internal and external virtual work are introduced. Kinematically admissible functions are defined; necessary and sufficient conditions for equilibrium are established. The unit-dummy displacement method is developed and applied to statically indeterminate truss. Virtual forces and complementary virtual work concepts are explored, and equilibrium conditions are found in terms of them. The unit-dummy load technique is developed and applied; the chapter closes with a discussion on statically indeterminate systems.

Energy principles and applications are the subjects of Chapter 9. The authors use the displacement version of the virtual work principle to show that, for static equilibrium, the total potential energy has a stationary value, a relative minimum for a stable state. The Rayleigh-Ritz method and Castigliano's first theorem are developed and applied. A modest account of a finite element scheme is given for plane stress; attention is confined to triangular elements and linear shape functions. The principle of stationary complementary energy is explored. Engesser's first theorem and, from it, Castigliano's second theorem are derived. Applications include curved bars, plane trusses, and a nonlinear elastic beam. The reciprocity theorems of Rayleigh-Betti and Maxwell are mentioned briefly. Attention is then focused on Engesser's second theorem. The chapter closes with applications to statically indeterminate systems.

Isotropic plate bending is treated in Chapter 10. Thin plate theory is derived in a standard fashion. The implication that St. Venant's principle is only approximate in the discussion of the Kirchhoff boundary condition at a free edge could confuse a student. Fourier series and Levy's method are used to obtain solutions for rectangular plates, including those on an elastic foundation. Energy methods are used to obtain approximate results for problems with no closed-form solutions. Chain rule differentiation leads to equations for circular plates. Solutions to several axisymmetric problems are given. Numerical solutions for rectangular plates are discussed. A description of a central difference scheme, including using fictitious boundary points to satisfy the boundary conditions, is given. The chapter ends with a brief treatment of a finite element scheme involving rectangular elements and bicubic shape functions. On page 400, L should be L_y.

A set of comprehensive problems and a list of 79 references are given. English units are used.

R.A. Scott
Department of Applied Mechanical
and Engineering Science
University of Michigan
Ann Arbor, MI 48109

MSC/NASTRAN PRIMER
STATIC AND NORMAL MODES ANALYSIS

H.G. Schaeffer
Schaeffer Analysis, Inc., Mt. Vernon, NH
2nd Printing 1979, $28.50

Structural analysis has forged ahead by utilizing the finite element method. NASTRAN (NASA STRUCTURAL ANALYSIS) is a general purpose program that encompasses many fields, including aeroelasticity, heat transfer, and structural analysis. This book lists some of the advantages and disadvantages of using this program to solve static and dynamic problems. The MacNeal-Schwendler Corp. version (MSC) of NASTRAN is utilized by a number of organizations. The author did not intend to write a text on the theoretical aspects of dynamics, statics, and mechanics but does furnish information that will be helpful in understanding the contents of the program and how the computer cards can be used to perform a finite element calculation. The book consists of 13 chapters and three appendices. The author refers the reader to the more elaborate MSC/NASTRAN manuals for detailed explanations.

Chapter I is an introduction to NASTRAN. The bulk data deck defines the structural model; it specifies sets of constraints and/or loads and values of the parameters used in rigid or set formats. The executive control deck provides user control; it specifies rigid or user supplied formats and means for modifying DIRECT MATRIX ABSTRACTION PROGRAMMING (DMAP). The latter controls NASTRAN usage.

Chapters II and III describe matrix and index notation and illustrate the solution of matrix equations. Chapter IV describes the basic principles of elasticity -- plates and solids -- and contains a brief introduction to nonlinear problems in structural analysis.

Chapter V contains variational principles, which are based upon admissible displacements (geometric constraints, equilibrium conditions, and constitutive relations). The author concludes the chapter with a short discussion of strain energy and complementary strain energy.

Chapter VI introduces the reader to finite element (FE) formulation based upon stiffness. Beam bending and axial rod stiffness coefficients and the elemental mass matrix are derived. Chapter VII describes global analysis procedures performed on the elements and the stiffness matrix. Included are the specification of constraints, flexibility-stiffness transformation, and procedures for setting up computer cards. Proper sequencing of nodes and the Guyan static reduction method are given.

Chapters VIII and IX describe the behavioral functions for FE; i.e., shape functions and polynomial shape functions. These are directed toward two- and three-dimensional isoparametric elements. Various structural elements utilized in NASTRAN are derived, including elastic springs, stress elements, flat and curved isoparametric shell elements, rigid elements, spline fit, and weighted averages. The chapter concludes with examples of nonuniform beams, including tapered and open sections and a sandwich construction. A good explanation of the five-sided isoparametric element is given, as is a brief discussion of spline element (RSPLINE) and its application to changing mesh size. The reviewer would have preferred a longer discussion and illustrations of the use of this variable element in reducing a 20 node solid element to an eight node solid element to decrease computer time.

Chapter X considers material properties and includes isotropic, anisotropic, and orthotropic constants for two- and three-dimensional elements. An important feature is a tabular presentation of temperature-dependent materials. Chapters XI-XII are concerned with static external loads including thermal fields. Centripetal accelerations are briefly discussed, but no derivation is given of the complete geometrical and kinematic matrices required for proper design of centrifugal loading of rotating blades.

The concluding chapter focuses on normal mode analysis. The basic concepts are considered -- orthogonality, standard forms of eigenvalue problems, and consistent and lumped mass formulations. The important solution methods utilized in NASTRAN are the determinantal method, determinant search method, inverse power method, tridiagonal (Givens Method), and the Guyan's reduction method.

The reviewer considers this a good book for those intending to use NASTRAN. However, the larger expanded MSC/NASTRAN manuals must be used for more detailed explanations. Missing from the book is the procedure for determining stresses at node points from Gaussian points for an isoparametric element; such determinations are important in regions of high stress gradients. MSC has formulated a procedure that should have been included in the text.

The reviewer would like to see MSC/NASTRAN incorporate the wave front (frontal) method in solutions of eigenvalue problems. This efficient method is being utilized in a number of other general purpose finite element programs. The author has fulfilled his requirement, but the reviewer cautions that a great deal of study and practice are needed by individuals entering the field of NASTRAN program usage. This book belongs on the shelves of prospective and active users of NASTRAN.

H. Saunders
General Electric Company
1 River Road
Schenectady, NY 12345

SHORT COURSES

MARCH

CORRELATION AND SPECTRAL ANALYSIS FOR ENGINEERING AND SCIENTIFIC APPLICATIONS

Dates: March 23-26, 1982
Place: Boston, Massachusetts
Objective: This four-day short course covers important engineering applications of correlation and spectral analysis relative to acoustics, mechanical vibrations, system identification and fluid dynamics problems in the aerospace, automotive, industrial noise control, civil engineering and oceanographic fields. Applications include identification of system properties and response effects, estimation of time delays and propagation velocities, determination of energy sources, and utilization of practical statistical error formulas to evaluate results. Comprehensive methods are explained to solve single input/single output problems, single input/multiple output problems and multiple input/multiple output problems, where arbitrary correlation and coherence functions (ordinary, partial, multiple) can exist among the records. Participants will be able to have questions answered that are of concern to their own individual projects.

Contact: Continuing Education Institute, 10889 Wilshire Blvd., Suite 1030, Los Angeles, California 90024 - (213) 824-9545.

APRIL

DESIGN OF FIXED OFFSHORE PLATFORMS

Dates: April 5-16, 1982
Place: Austin, Texas
Objective: This course is dedicated to the professional development of those engineers, scientists, and technologists who are and will be designing fixed offshore platforms to function in the ocean environment from the present into the twenty-first century. The overall objective is to provide participants with an understanding of the design and construction of fixed platforms, specifically the theory and processes of such design and the use of current, applicable engineering methods.

Contact: Continuing Engineering Studies, College of Engineering, Ernest Cockrell Hall 2.102, The University of Texas, Austin, TX 78712 - (512) 471-3506.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: April 12-16, 1982
Place: Dayton, Ohio
Dates: July 19-23, 1982
Place: England
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

MACHINERY VIBRATION ANALYSIS

Dates: April 13-16, 1982
Place: Philadelphia, Pennsylvania
Dates: June 15-18, 1982
Place: Seattle, Washington
Dates: August 17-20, 1982
Place: New Orleans, Louisiana
Dates: November 9-12, 1982
Place: Oak Brook, Illinois
Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures

on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow speed paper rolls.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

EIGHTH ANNUAL RELIABILITY TESTING INSTITUTE

Dates: April 19-23, 1982

Place: Tucson, Arizona

Objective: This course is designed to provide reliability engineers and managers, product assurance and quality control and assurance engineers and managers and all other engineers and teachers with a working knowledge of: analyzing component, equipment, and system performance and failure data to determine the distributions of their times to failure, their failure rates, their reliabilities and their confidence limits; planning small sample size, short duration, low-cost tests and analyzing their results; conducting accelerated testing, Bayesian testing, suspended items testing, sequential testing, and others.

Contact: Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Department, The University of Arizona, Building 16, Tucson, AZ 85721 - (602) 626-2495.

MAY

ADVANCED RANDOM DATA ANALYSIS AND APPLICATIONS

Dates: May 3-7, 1982

Place: Los Angeles, California

Objective: The course is designed for engineers, scientists, technical managers, mathematicians and computer specialists who deal with analysis, interpretation of results, and current engineering applications of random data analysis. The course covers the latest practical techniques of correlation and spectral analysis to solve problems in physical systems. Procedures currently being applied to data collected from single, multiple and distributed input/output systems are explained to: classify data and systems; measure propagation times; identify source contributions; evaluate and monitor system properties; predict output responses and noise conditions; determine nonlinear and nonstationary effects; conduct dynamics test programs; and perform digital data analysis.

Contact: Short Course Program Office, UCLA Extension, P.O. Box 24901, Los Angeles, CA 90024 - (213) 825-1295 or 825-3344.

ROTORDYNAMICS OF TURBOMACHINERY

Dates: May 17-19, 1982

Place: College Station, Texas

Objective: To provide a bridge between dynamics theory and the typical hands-on vibrations/instrumentation short course for the engineer who needs a basic understanding of practical turbomachinery rotordynamics. The course will treat balancing, rotordynamic instability, and torsional vibration problems. Fundamentals of each area will be followed up by case histories from engineering practice.

Contact: Dr. John M. Vance, Department of Mechanical Engineering, Texas A&M University, College Station, TX 77843 - (713) 845-1257.

FUNDAMENTALS OF TURBOMACHINERY PERFORMANCE

Dates: May 19-21, 1982

Place: College Station, Texas

Objective: The fundamental analysis and applications of the performance of various types of turbomachines will be presented for the engineer seeking a basic understanding of the operation of turbomachinery. A "hands-on" session will be held in conjunction with a problem solving session in order to provide some experience in using the performance analysis concepts. Also, several experienced engineers from industry will provide insight into the opera-

tional and maintenance problems associated with several types of turbomachines.

Contact: Dr. Peter E. Jenkins, Department of Mechanical Engineering, Texas A&M University, College Station, TX 77843 - (713) 845-7417.

JUNE

VIBRATION DAMPING

Dates: June 14-17, 1982

Place: Dayton, Ohio

Objective: The utilization of the vibration damping properties of viscoelastic materials to reduce structural vibration and noise has become well developed and successfully demonstrated in recent years. The course is intended to give the participant an understanding of the principles of vibration damping necessary for the successful application of this technology. Topics included are: damping fundamentals, damping behavior of materials, response measurements of damped systems, layered damping treatments, tuned dampers, finite element techniques, case histories, and problem solving sessions.

Contact: Michael L. Drake, Kettering Laboratory 23, 300 College Park Avenue, Dayton, OH 45469 - (513) 229-2644.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

PROCEEDINGS AVAILABLE FOR THE
INTERNATIONAL CONGRESS ON ACOUSTIC INTENSITY MEASUREMENT
Senlis (France)
September 30 - October 2, 1981

The first International Congress on Acoustic Intensity Measurement has been held at Centre Technique des Industries Mecaniques. Forty papers were presented and at the Technical Exhibition six firms displayed specific instrumentation for intensity measurement. The unexpected high attendance of 230 persons from 22 countries proved the growing interest for this technique not only in the university laboratories but also in the mechanical, aerospace and automotive industries.

Proceedings are available from: CETIM, Service Publication, B.P. 67, F - 60304. SENLIS (France); Price: 180 FF.

Now Available
THE ENVIRONMENTAL QUALIFICATION SPECIFICATION
AS A TECHNICAL MANAGEMENT TOOL
by Charles T. Morrow

A Special Publication of The Shock and Vibration
Information Center
Naval Research Laboratory, Washington, DC

Environmental qualification specifications prescribe shock and vibration conditions for use in test at the end of development as a verification of design adequacy. Such specifications can also serve as technical management tools during the development process. This report is a study of the effectiveness of qualification specifications in this technical management role and of means for improving this effectiveness. It is intended for any reader, administrative or technical, who influences initial decisions concerning shock and vibration approaches, or the specifications and accepted practices underlying such decisions.

Chapter 1 is an introduction and description of the study. Chapters 2 and 3 discuss the decision process related specifically to specifications applicable to packaging and isolation, based largely on a survey conducted in these areas. Chapter 4 offers some recommendations for change to improve the cost/effectiveness ratio with respect to isolation and packaging development problems. By far the most important part of this report is Chapter 5, which contains some recommended changes in MIL-STD-810 and related specifications to improve the cost/effectiveness of shock and vibration engineering more generally. The body of the publication is supported by appropriate appendices. 120 pages (November 1981).

INFORMATION RESOURCES

COASTAL ENGINEERING INFORMATION AND ANALYSIS CENTER (CEIAC)

In support of the Coastal Engineering Research Center (CERC), this Coastal Engineering Information and Analysis Center is responsible for storage and dissemination of data related to coastal engineering and replying to requests for information. CEIAC is responsible for furnishing on request to other Government agencies and the general public the CERC publications remaining after the initial distribution by the Publications Branch as long as the supply lasts.

The Coastal Engineering Research Center (CERC) is the principal research and development facility of the U.S. Army Corps of Engineers in the field of coastal engineering, with application to Corps missions in shore and beach erosion control; coastal flood and storm protection; recreation; navigation improvement; and the location, layout, design and construction, operation, and maintenance of harbors. The program encompasses the disciplinary areas of coastal hydraulics, coastal sediments, coastal structures, and coastal ecology and their interrelationships. CERC's research and development program is aimed at developing relationships and guidelines which can be used to arrive at effective solutions to real coastal engineering problems. The mission of CERC is to conceive, plan, and conduct research and data collection in coastal engineering and nearshore oceanography to:

- provide a better understanding of the littoral forces (winds, waves, tides, and currents) and the resultant coastal processes, and the interaction of these forces and processes with shores and beaches, coastal and offshore structures, and the materials forming these shores, beaches, and structures
- determine scientific engineering data and design criteria
- determine the effects of the Corps' engineering activities on the ecology of the coastal zone

The results of research conducted at CERC are published for use by the Corps of Engineers and the public. In addition to research, CERC provides consulting services in coastal engineering to the Corps of Engineers and other public agencies as requested or directed:

- on the planning and design of coastal and offshore works
- on coastal and nearshore phenomena and related engineering and environmental problems
- by reviewing studies, and plans and specifications for coastal and offshore engineering works

The Publications Branch is responsible for reviewing, editing, preparing in reproducible form, and initial distribution of all technical manuscripts resulting from research projects under CERC's direction. The Publications Branch is also responsible for arranging publication exchange agreements with foreign institutions engaged in similar work.

CERC's library provides a full range of library services and technical literature resources. The collection is the result of the amalgamation of the collections of the Coastal Engineering Research Center, the Water Resources Support Center (WRSC), and the Board of Engineers for Rivers and Harbors (BERH) and serves as a central source of technical information in those engineering scientific fields in which the CERC, BERH, and WRSC have an interest.

The collection is one of the nation's most extensive in subject matter areas of coastal engineering, consisting of approximately 40,000 books, 63,000 reports, 5,000 periodicals, and 3,100 microforms. In addition to normal acquisitions by gift or purchase, the collection is kept current by exchanges with leading engineering, scientific, and educational institutions both in the United States and abroad. It is staffed by professional librarians, and can supply (on loan) out-of-print publications of CERC and the Beach Erosion Board.

Please call or visit the CEIAC if you require information in these areas. They are located in the Kingman Building near Fort Belvoir. Mr. Dennis Berg is the Director, or inquiries may be directed to Audre Szuwalski or Linda Clark. The address is:

Coastal Engineering Information and Analysis Center
Department of the Army
Corps of Engineers
Kingman Building
Fort Belvoir, Virginia 22060
(202) 325-7386

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

Rotating Machines
Reciprocating Machines
Power Transmission Systems
Metal Working and Forming
Isolation and Absorption
Electromechanical Systems
Optical Systems
Materials Handling Equipment

STRUCTURAL SYSTEMS

Bridges
Buildings
Towers
Foundations
Underground Structures
Harbors and Dams
Roads and Tracks
Construction Equipment
Pressure Vessels
Power Plants
Off-shore Structures

VEHICLE SYSTEMS

Ground Vehicles
Ships
Aircraft
Missiles and Spacecraft

BIOLOGICAL SYSTEMS

Human
Animal

MECHANICAL COMPONENTS

Absorbers and Isolators
Springs
Tires and Wheels
Blades
Bearings
Belts
Gears
Clutches
Couplings
Fasteners
Linkages
Valves
Seals
Cams

STRUCTURAL COMPONENTS

Strings and Ropes
Cables
Bars and Rods
Beams
Cylinders
Columns
Frames and Arches
Membranes, Films, and Webs
Panels
Plates
Shells
Rings
Pipes and Tubes
Ducts
Building Components

ELECTRIC COMPONENTS

Controls (Switches, Circuit Breakers)
Motors
Generators
Transformers
Relays
Electronic Components

DYNAMIC ENVIRONMENT

Acoustic Excitation
Shock Excitation
Vibration Excitation
Thermal Excitation

MECHANICAL PROPERTIES

Damping
Fatigue
Elasticity and Plasticity

EXPERIMENTATION

Measurement and Analysis
Dynamic Tests
Scaling and Modeling
Diagnostics
Balancing
Monitoring

ANALYSIS AND DESIGN

Analogs and Analog
Computation
Analytical Methods
Modeling Techniques
Nonlinear Analysis
Numerical Methods
Statistical Methods
Parameter Identification
Mobility/Impedance Methods
Optimization Techniques
Design Techniques
Computer Programs

GENERAL TOPICS

Conference Proceedings
Tutorials and Reviews
Criteria, Standards, and
Specifications
Bibliographies
Useful Applications

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, DC 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

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MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 730, 738, 739, 743)

82-555

An Improved Method for Calculating Critical Speeds and Rotordynamics Stability of Turbomachinery

B.T. Murphy and J.M. Vance
Dept. of Mech. Engrg., Texas A&M Univ., College Station, TX, Turbomachinery Symp., Proc. of the 10th, held Dec 1-3, 1981, Texas A&M Univ., College Station, TX, pp 141-145, 7 figs, 12 refs

Key Words: Rotors, Turbomachinery, Critical speeds, Computer programs, Transfer matrix methods

A number of the computer programs for rotordynamic stability and critical speed prediction in common use during recent years have been based on the works of Myklestad, Prohl and Lund. Programs of this type, called transfer matrix programs, employ complex variables when damping or cross-coupling is included in the model. Most use an iteration scheme which at times fails to converge with sufficient accuracy on some critical speeds, and has been known to completely miss critical speeds on occasion. It is shown in this paper that by rearranging the calculations performed in a transfer matrix program one can derive the characteristic polynomial for a complex rotor-bearing system, with no loss in generality.

82-556

Experimental Determination of Lateral Vibration of the 708 MVA Westinghouse Vertical Hydro Generators at Grand Coulee Dam, Washington

R.L. Turner
Westinghouse Electric Corp., East Pittsburgh, PA, ASME Paper No. 81-DET-70

Key Words: Lateral vibration, Rotors, Bearings, Pumps, Hydroelectric power plants, Power plants (facilities)

The damped rotor bearing system of large vertical shaft systems presents special problems for high speed pump storage installations. With the emergence of this new technology, experimental verification of the behavior of large vertical shaft systems is essential. The results of the first test of its kind have given experimental data contributing to this technology.

82-557

Diesel Crankshaft Failures in Marine Industry – A Variable Inertia Aspect

M.S. Pasricha and W.D. Carnegie
Dept. of Mech. Engrg., The Papua New Guinea Univ. of Tech., P.O. Box 793, LAE, Papua New Guinea, J. Sound Vib., 78 (3), pp 347-354 (Oct 8, 1981) 5 figs, 17 refs

Key Words: Crankshafts, Diesel engines, Marine engines, Torsional vibration, Failure analysis

In recent years several cases of failures of engineering systems in practice have been attributed to the effect of variable inertia or to the periodic pulsation in the spring constant. Violent torsional vibrations in the systems have been observed in several speed ranges resulting in failure and only a partial explanation of the behavior of the systems has been worked out. In the present paper a critical appraisal of the regions of instability as determined by using different considerations is given, also for a single cylinder engine to avoid greater complexities. By treating Draminsky's equation as a linear equation with variable coefficients, solutions have been worked out by use of numerical analysis techniques aided by a digital computer to predict the exact waveforms of the motion and the regions of instability.

82-558

Nonstationary Vibration During Acceleration through Two Critical Speeds (Maximum Amplitudes and Their Rotational Speeds)

S. Yanabe
Technological Univ. of Nagaoka, Kamitimioka Aza Nagamine 1603-1, Nagaoka-Shi, Niigata-Ken, 949-54, Bull. JSME, 24 (196), pp 1820-1825 (Oct 1981) 8 figs, 9 refs

Key Words: Shafts, Critical speeds, Resonance pass through

Taking account of damping effects, the nonstationary vibration during angular acceleration of a shaft through two critical speeds situated close together is analyzed theoretically, and both an exact solution and approximate expressions for it are derived. The results obtained from calculations of the exact solution show that the rotational speed

at which the highest maximum amplitude will occur varies in a sawtooth manner above a certain acceleration rate, and that the highest maximum amplitude does not always decrease as the acceleration increases. A method for evaluating both the maximum amplitude and its rotational speed is proposed on the basis of the analytical results, and the evaluated values are compared with those from the exact solution.

82-559

Experimental Research on Stress Fluctuations in Runner Vanes of High-Head Pump-Turbines

Y. Yamaguchi and H. Ito
Mech. Engrg. Res. Lab., Hitachi, Ltd., Saiwai-cho 3-1-1, Hitachi-shi, Japan, Bull. JSME, 24 (195), pp 1594-1601 (Sept 1981) 9 figs, 3 tables, 4 refs

Key Words: Pumps, Turbine components, Fluid-induced excitation

By measuring stress fluctuations in runner vanes of a prototype 500 m class Francis-type pump-turbine and a 1/12 reduced scale model of that pump-turbine, it was revealed that the stress fluctuations consist of components of higher harmonics of runner speed n, components whose frequencies are constant, that is, independent of runner speed, and components caused by interference from the wicket gates. The 1st components are generated by an unequal distribution of flow properties on the periphery of the runner. The 2nd components are estimated as components of acoustic resonance in flow paths very close to the runner. Comparisons of the prototype and the model are made about the overall amplitude and amplitudes of major frequency components of the stress fluctuations.

82-560

An Experiment on Pump Pressure Fluctuation, Vibration and Air Borne Noise Caused by Cavitation

S. Saito and M. Oshima
Ebara Corp., Tokyo, Japan, ASME Paper No. 81-DET-94

Key Words: Pumps, Cavitation, Vibration excitation, Cavitation noise, Noise measurement

Pressure fluctuation, casing vibration and air borne noise were measured on an axial flow pump under various cavitation conditions, and the relationship between these phenomena was investigated. It was found that the pressure fluctuation, casing vibration and air borne noise are most intensive at the side of the impeller.

82-561

Fan/Foundation Interaction – A Simplified Calculation Procedure

H.M. Chen and S.B. Malanoski
Mechanical Technology, Inc., Latham, NY, J. Engrg. Power, 103 (4), pp 805-810 (Oct 1981) 4 figs, 1 table, 2 refs

Key Words: Fans, Interaction: structure-foundation

This paper presents a simplified analysis procedure to provide initial assessment and guidance on fan rotor dynamics including the foundation interaction. For purposes of early-design decision-making (or trouble-shooting), the interaction of a rotor-bearing dynamic system and a foundation-soil/piling dynamic system is viewed approximately for the vertical, horizontal, and rocking modes of vibration. The equations of motion are written in matrix form and include the pertinent parameters. A numerical example is presented to guide in the interpretation of the analysis; this example considers the unbalance response of the entire system as measured at the bearings.

RECIPROCATING MACHINES

82-562

The Use of Existing and Advanced Intensity Techniques to Identify Noise Sources on a Diesel Engine

M.J. Crocker
Purdue Univ., SAE Paper No. 810694

Key Words: Diesel engines, Noise source identification

Existing techniques for identifying noise sources are reviewed. One such technique (the lead-wrapping approach) was used to source-identify a diesel engine and measure the sound power radiated from the major surfaces. Two new advanced techniques (surface intensity and acoustic intensity) were developed and used to measure the sound power radiated from the same major surfaces. The conventional lead-wrapping and new intensity results were compared and agreement was good. The advantages of the new intensity techniques are described and suggestions made for reducing the noise of this and other similar diesel engines.

82-563

Application of Vibration and Acoustics Technology in the Development of the Porsche 944 Engine (Schwingungstechnisch-akustische Massnahmen bei der Entwicklung des Porsche 944-Motors)

R. von Sivers and R. Pilgrim

Automobiltechnische Z., 83 (11), pp 583-586, 589, 590 (Nov 1981) 11 figs, 1 table, 7 refs

(In German)

Key Words: Automobile engines, Harmonic excitation, Torque, Vibration control

Basic studies have revealed a smooth engine running can be achieved by means of a modified Lancestercounterbalance system, despite of the large capacity of the 4-cylinder in-line engine derived from the Porsche 928-V8. The typical 4-cylinder in-line-layout 2nd-order harmonic forces and torques can be compensated almost completely by means of two counter balancing shafts mounted with a vertical offset. In combination with other dynamical improvements the smooth behavior of the 6-cylinder-type engine could be matched without giving up the 4-cylinder-type advantages.

POWER TRANSMISSION SYSTEMS

(See No. 630)

METAL WORKING AND FORMING

82-564

Effects of Process Parameters on Hammer Noise

S. Vajpayee and M.M. Sadek

Univ. of Birmingham, UK, ASME Paper No. 81-DET-95

Key Words: Hammers, Impact noise, Metal working

Of the various forming process parameters affecting the level of noise generated in impact forming, only two -- the billet diameter and input energy, have been found to be the most significant. This work summarizes the results of tests carried out on a high-energy-rate-forming machine to investigate the influence of these two parameters on the strength of vaious impulsive noise generating mechanisms.

MATERIALS HANDLING EQUIPMENT

82-565

Nondestructive Testing to Obtain Motion and Force Coefficients by Simulating the Actual System (Verlustlose Bestimmung von Bewegungs- und Kraftgrössen mittels der Simulation von Realsystemen)

D. Severin and V. Schenk

Inst. f. Fördertechnik und Getriebetechnik der TU, Berlin, Germany, Konstruktion, 33 (9), pp 351-359 (Sept 1981) 27 figs, 14 refs (In German)

Key Words: Conveyors, Materials handling equipment, Force coefficients

The motion and force coefficients acting on a system can be determined by measuring several other quantities acting on the system and using them as input into a mathematical model. A measured coefficient of motion is used as the input into the mathematical model. The required controlled output is the force coefficient. The technique is illustrated in an analysis of a roller-belt conveyor.

STRUCTURAL SYSTEMS

BRIDGES

82-566

Floating Bridge Drawspan Maintenance

C.B. Brown, D.R. Christensen, J.W. Heavner, M.A. Landy, and R. Vasu

Dept. of Civil Engrg., Univ. of Washington, Seattle, WA 98195, ASCE J. Struc. Div., 107 (11), pp 2127-2146 (Nov 1981) 7 figs, 14 tables, 4 refs

Key Words: Bridges, Pontoon bridges, Fatigue life

A methodology for making maintenance decisions to avoid fatigue failure is proposed. The maintenance procedures developed for the drawspan mechanism of the Evergreen Point Bridge are used as an illustration of the methodology. The methodology includes development of the stress/environment relationship for the critical member, collection of long-term environmental data and the computation of long-term stress distribution, determination of cycles at each stress level from the return period, and duration of various environmental conditions and the member frequency at the

associated stress level, determination of the fatigue characteristics of the member (S-N) from a limited number of full-scale tests.

BUILDINGS

82-567

Procedure for Predicting Wind Damage to Buildings

K.C. Mehta, J.R. McDonald, and D.A. Smith

Dept. of Civil Engrg., Texas Tech Univ., P.O. Box 4089, Lubbock, TX 79409, ASCE J. Struc. Div., 107 (11), pp 2089-2096 (Nov 1981) 1 fig, 4 tables, 7 refs

Key Words: Buildings, Wind-induced excitation, Damage prediction

Experience gained from post-storm investigations of damaged buildings has made it possible to predict types of damage expected on existing buildings. Two procedures that involve different levels of engineering effort are outlined in the paper to predict wind damage to buildings.

82-568

Structural Dynamics and Control of Large Space Structures

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-CP-2187, L-14609, 136 pp (June 1981) (Proc. held at Hampton, VA, Oct 30-31, 1980)

N81-26166

Key Words: Structural response, Dynamic response

The focus of the workshop was the basic research program assembled to address the fundamental technology deficiencies that were identified in several studies on large space systems conducted by NASA in the last several years. The staffs of the respective participants were assembled at the workshop to review the current state of research in the control technology for large structural systems and to plan the efforts that would be pursued by their respective organizations.

CONSTRUCTION EQUIPMENT

82-569

An Example of Noise Control Treatment for Construction Machinery Cab Interiors

W. Nakkula, Jr., R. Zimmerli, and R. Borough

Globe Industries, SAE Paper No. 810698

Key Words: Construction equipment, Noise reduction, Automobile noise

The effect of noise on the operator has become of increasing concern to manufacturers of construction machinery in recent years. Although the noise generated by heavy duty construction equipment is much greater when compared to other types of machines such as the passenger car, the problems are similar. Many of the lessons learned in reducing interior noise within the automobile can be used to reduce noise within the operator's cab of construction machinery.

82-570

Modeling Directionally Radiating Acoustical Enclosures to Determine Noise Levels

E. O'Keefe

Clark Equipment Co., Construction Machinery Div., Benton Harbor, MI, SAE Paper No. 810699

Key Words: Mathematical models, Enclosures, Acoustic diffraction, Constrution equipment, Noise reduction

A computer modeling procedure has been developed to assess the effect of an enclosure on far-field noise levels. The model accounts for directional radiation patterns and enclosure diffraction effects for each of the six sides. Comparisons between predictions and test measurements show good agreement.

PRESSURE VESSELS

82-571

On Stress-Strain Relations Suitable for Cyclic and Other Loading

D.C. Drucker and L. Palgen

College of Engrg., Univ. of Illinois, Urbana, IL, J. Appl. Mechanics, Trans. ASME, 48 (3), pp 479-485 (Sept 1981) 9 figs, 22 refs

Key Words: Pressure vessels, Cyclic loading

The analysis and design of pressure vessels and other structures subjected to cyclic loading and occasional large overloads requires stress-strain relations sufficiently simple to be usable with computer programs and yet adequate to describe the essential aspects of the response of the material.

One such form with two quite different options is proposed for the time-independent domain which avoids the difficulties of earlier approaches. It has the kinematic hardening attributes needed for reversal of loading, allows for cyclic hardening or softening, gives zero mean stress as the asymptotic response to cyclic straining between fixed limits of strain, and reduces to a stress-hardening form for radial or proportional loading so that it can model both cyclic and other loading to a good first approximation.

POWER PLANTS

(Also see Nos. 556, 611)

82-572

Method of Analysis of CRBRP Transients for the Steam Generator

A.V. von Arx
Rockwell International, Canoga Park, CA, ASME Paper No. 81-JPGC-NE-5

Key Words: Nuclear power plants, Boilers, Transient response

In a nuclear power plant such as the Clinch River Breeder Reactor Plant, there is a large number of transients which have to be analyzed. The analysis is required to demonstrate the structural integrity of the various components. The task of analyzing each of these events for the several zones that are required to be evaluated becomes a very costly operation in terms of manpower and computer usage. A method has been developed to select only a few representative transients which are defined as umbrella transients. This approach reduces the number of events to be analyzed on a given component, such as the steam generator, from over one hundred to less than ten and has proven to be cost effective.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 717, 718, 719, 728)

82-573

The Development of a National Traffic Noise Abatement Program in Norway

T.E. Granquist
Akershus County, St. Olavs Plass 3, Oslo 1, Norway
Noise Control Engrg., 17 (2), pp 71-75 (Sept-Oct 1981) 2 figs, 4 tables, 5 refs

Key Words: Traffic noise, Noise reduction

In order to develop a national traffic noise abatement program, the existing traffic noise climate was mapped. A description of how the mapping of the traffic noise was carried out is given.

82-574

Jumps and Bumps on Random Loads

G. Lindgren
Dept. of Math. Statistics, Lund Inst. of Tech., Box 725, S-220 07 Lund, Sweden, J. Sound Vib., 78 (3), pp 383-395 (Oct 8, 1981) 7 figs, 10 refs

Key Words: Automobiles, Surface roughness, Random excitation

When a car travels on a randomly profiled road at a moderate speed the wheels follow the road, but with increasing speed it can happen that a wheel leaves the ground for a short while – it jumps and bumps. A switching stochastic differential equation is presented for simulation and probabilistic analysis of the movements of the car, in particular after a jump. A simulation study illustrates the effects on the vertical accelerations of the non-linearity induced by the jumps. The conditional distributions of the road and wheel elevations after a jump are described by means of a Slepian model process, giving, e.g., the average behavior after a jump.

82-575

Front Wheel Drive Vehicle Crashworthiness

E. Franchini
FIAT Safety Ctr., SAE Paper No. 810790

Key Words: Automobiles, Crashworthiness, Collision research (automotive)

An analysis is carried out on the collision behavior of front engine/front drive cars in comparison with the other main types such as front engine/rear drive and rear engine/rear drive. An evaluation is made of the results of standardized collision tests, integrated with non-standardized tests with particular devices.

82-576

Modeling and Simulation of Frontal Crash Impact Response

K. Kurimoto, H. Nakaya, and K. Okada

Toyo Kogyo Co., Ltd., Japan, SAE Paper No. 810793

Key Words: Collision research (automotive), Mathematical models

The capability to predict the response of a vehicle body structure to frontal barrier crash is examined by a vehicle model represented by various lumped mass and non-linear resistance systems from that of one dimensional with minimal degrees of freedom to these of two dimensions and several degrees of freedom. Comparison between numerical calculation and full scale experiment demonstrates that on even a simple representation, the calculations are in good agreement with the experiment.

82-577

Handling, Braking, and Crash Compatibility Aspects of Small, Front-Wheel Drive Vehicles

W. Dreyer, B. Richter, and R. Zobel

Volkswagenwerk AG, SAE Paper No. 810792

Key Words: Collision research (automotive), Ride dynamics, Braking effects

A mathematical model is used to compare the dynamic handling characteristics of four different vehicle concepts: front engine/front-wheel drive, front engine/rear-wheel drive, rear engine/front-wheel drive, and rear engine/rear-wheel drive. The second section of this paper deals with the design considerations posed by small, front-wheel drive vehicles in regard to the proper proportioning of the brake force distribution with a particular view to braking distance and directional control behavior of the vehicle during brake input. The third section is a study of the vehicle-to-vehicle collision based on current statistics. An effort is made to provide an interpretation of tne distribution of accident fatalities in collisions between large and small vehicles.

82-578

Off-Road Machine Operator Vibration Measurement Methods

J.C. Barton

Caterpillar Tractor Co., SAE Paper No. 810695

Key Words: Off-highway vehicles Human response, Random excitation

Analysis of off-road machine operator vibration data shows that the methods of absorbed power and amplitude-frequency distribution provide no information beyond that expressed by the frequency weighted overall rms acceleration of SAE J1013 and ISO 2631. The probability density functions of the data are Gaussian in both broad band and narrow band analysis. "Crest factor" is a meaningless descriptor of the data. As shown by examples, failure to consider the statistical precision of the random data results in erroneous time domain and frequency domain statistics.

82-579

Design of Aluminum Bicycle Frames

R. Davis and M.L. Hull

Dept. of Mech. Engrg., Univ. of California, Davis, CA 95616, J. Mech. Des., Trans. ASME, 103 (4), pp 901-907 (Oct 1981) 8 figs, 6 tables, 17 refs

Key Words: Bicycles, Fatigue life, Computer programs, Finite element technique

This paper presents the use of a hybrid stress analysis method for the prediction of fatigue life of bicycle frames. A finite beam element computer program is used to calculate frame stresses. In order to correlate the results with actual frame stresses, brittle coating experiments are conducted on an aluminum frame. Strain gage experiments, guided by the brittle coating results, provide more accurate measurements of maximum principal stresses. Stress concentration factors are defined, the fatigue life of an aluminum frame is predicted for a simple loading condition, and the result is compared with in-service failure data.

SHIPS

(Also see No. 557)

82-580

Transfer of Structureborne Sound to Ships' Cabins

M.J.A.M. de Regt

TPD, Inst. of Applied Physics, Postbus 155, 2600 AD Delft, The Netherlands, Noise Control Engrg., 17 (2), pp 58-63 (Sept-Oct 1981) 11 figs, 10 refs

Key Words: Ships, Ship cabins, Structure-borne noise

The transfer of structureborne sound from a ship-like steel structure into a cabin has been investigated in the laboratory for three types of cabin bulkhead material: chipboard, plastic faced calcium silicate and steel plates sandwiching a rockwool

core. The following results are discussed: the influence of the applied materials for bulkheads and ceiling on the resulting sound pressure level in the cabin, the effect of the installation of a floating floor and the effect of the presence of a porthole. Estimates are given for the attainable insertion losses of floating floors on board ships under various conditions.

82-581

Formulas and Procedures for Estimating the Collapse Loads of Ship Structural Members

P.Y. Chang

Hydronautics, Inc., Laurel, MD, Rept. No. TR-8029-2, MA-RD-940 81066, 66 pp (May 28, 1980) PB81-221855

Key Words: Structural members, Ships, Collision research (ships)

Formulas and procedures for the estimating collapse loads of ship structural members are presented. These formulas are essential for the determination of the velocity field for the analysis of the collapse loads of ship structures in collision.

82-582

Structural Analysis of the Collapsing Bow of a Striking Ship

P.Y. Chang and C. Thasanatorn

Hydronautics, Inc., Laurel, MD, Rept. No. TR-8029-1, MA-RD-940-81065, 128 pp (May 28, 1980) PB81-221848

Key Words: Ships, Ship hulls, Collision research (ships), Computer programs

A mathematical model and structural dynamic computer program have been developed for the analysis of the collapsing bow of a striking ship. The model can be used to predict the collision impact force and the extent of damage of the striking ship bow in both perpendicular and oblique collision. The ice breaker POLAR STAR was used as an example for testing the computer program for an oblique collision angle.

AIRCRAFT

82-583

Summary of Typical Parameters that Affect Sound Transmission through General Aviation Aircraft Structures

F Grosveld, R. Navaneethan, and J. Roskam

Flight Res. Lab., Univ. of Kansas, Lawrence, KS, SAE Paper No. 810562

Key Words: Aircraft noise, Sound transmission, Interior noise

This paper presents results of a systematic experimental investigation of parameters which affect sound transmission through general aviation structures. Parameters studied include angle of sound incidence, panel curvature, panel stresses, and edge conditions for bare panels; pane thickness, spacing, inclination of window panes, and depressurization for dual pane windows; densities of hard foam and sound absorption materials, air gaps, and trim panel thickness for multilayered panels. Based on the study, some promising methods for reducing interior noise in general aviation airplanes are discussed.

82-584

A Prediction Procedure for Propeller Aircraft Flyover Noise Based on Empirical Data

M.H. Smith

Cessna Aircraft Co., SAE Paper No. 810604

Key Words: Aircraft noise, Noise prediction, Regression analysis

Forty-eight different flyover noise certification tests are analyzed using multiple linear regression methods. A prediction model is presented based on this analysis, and the results compared with the test data and the two other prediction methods. The aircraft analyzed include 30 single engine aircraft, 16 twin engine piston aircraft, and two twin engine turboprops. The importance of helical tip Mach number is verified and the relationship of several other aircraft, engine, and propeller parameters is developed. The model shows good agreement with the test data and is at least as accurate as the other prediction methods. It has the advantage of being somewhat easier to use since it is in the form of a single equation.

82-585

Comparison of Aircraft Noise-Contour Prediction Programs

R.L. Chapkis, G.L. Blankenship, and A.H. Marsh

DyTec Engrg., Inc., Long Beach, CA, J. Aircraft, 18 (11), pp 926-933 (Nov 1981) 7 figs, 3 tables, 21 refs

Key Words: Aircraft, Computer programs, Noise prediction

A comparison was made of the FAA Integrated Noise Model and the USAF/NOISEMAP computer programs. Those programs are widely used to predict the location of aircraft noise contours around airports and to determine the size of the areas enclosed. Large differences were found in the noise data bases. There were also differences in flight-profile data bases, ground attenuation factor, and in the way the change in noise duration is handled for curved flight paths. The two programs were used to calculate sound exposure level contours produced by individual operations of various air-carrier and general-aviation jets.

82 586

The Development of a Flyover Noise Prediction Technique Using Multiple Linear Regression Analysis

R.K. Rathgeber

Cessna Aircraft Co., SAE Paper No. 810588

Key Words: Aircraft noise, Propeller noise, Noise prediction, Regression analysis

At Cessna Aircraft Company, statistical analyses have been developed to define important trends in flyover noise data. Multiple regression techniques have provided the means to develop flyover noise prediction methods which have resulted in better accuracy than methods used in the past. Regression analyses have been conducted to determine the important relationship between propeller helical tip Mach number and the flyover noise level. Other variables have been included in the regression models either because the added variable contributed to reducing the remaining variation in the model or the variable appeared to be a strong causal agent of flyover noise.

82 587

Propeller Signatures and Their Use

J.F. Johnston, R.E. Donham, and W.A. Guinn

Lockheed-California Company, Burbank, CA, J. Aircraft, 18 (11), pp 934-942 (Nov 1981) 19 figs, 1 table

Key Words: Signal processing techniques, Acoustic signatures, Vibration signatures, Aircraft noise, Propeller noise, Noise reduction

The identification and use of the noise and vibration signatures of individual propellers, described herein, has provided a basis for rational advances in propeller-noise analysis and control. These signatures, or influence vectors, were used for analytically determining optimum synchrophase angles and diagnosing the specific paths -- airborne and structure-borne -- of the noise into the cabin. A number of significant conclusions are drawn from flight experiments in a Navy P-3C patrol aircraft. The results and techniques from this work are applicable to improving the passenger and crew comfort as well as equipment life in propeller-powered aircraft.

82-588

Helicopter Noise -- Is Technology the Answer?

R.J. King

Hughes Helicopters, SAE Paper No. 810591

Key Words: Helicopter noise, Noise reduction

Noise will be reduced substantially for upcoming helicopter generations. User, community, and new regulatory requirements have combined to increase the priority of noise in helicopter design. This presentation summarizes the writer's interpretation of: industry concerns in helicopter noise rulemaking, some of the technical challenges facing the industry in complying with them, the areas over and above regulatory requirements where work is needed to improve helicopter acceptance from a noise point of view, and some recommendations for developing the technology for noise control with acceptable performance/economic consequences.

82-589

Strategies for Aircraft Interior Noise Reduction in Existing and Future Propeller Aircraft

F.B. Metzger

Hamilton Standard, SAE Paper No. 810560

Key Words: Aircraft noise, Propeller noise, Interior noise, Noise reduction

Airline deregulation and the high cost of fuel have caused a renewed interest in propeller-driven aircraft as a replacement for existing turbofan aircraft. Since passengers on existing turbofan aircraft have become accustomed to lower interior noise than exists in current propeller aircraft, there has been a renewed interest in interior noise control by reduction of propeller source noise, by design of lightweight fuselage soundproofing and other noise reduction concepts. This paper discusses the noise control problem from a source noise and aircraft design standpoint. The existing state-of-the-art is reviewed and the promising strategies for reducing noise in propeller aircraft are discussed.

82-590

Noise Transmission and Attenuation for Business Aircraft

R. Vaicaitis, M.T. Chang, and M. Slazak
Columbia Univ., New York, NY, SAE Paper No. 810561

Key Words: Aircraft noise, Noise reduction, Interior noise, Panels

This paper describes analytical studies applicable for estimating the effects of noise transmission into light aircraft and commuter type aircraft. The propeller noise and turbulent boundary layer noise are considered. The analytical model described uses modal methods and incorporates flat stiffened panels for flat sided sidewalls and curved stiffened panels for cylindrical enclosures. The numerical results include noise attenuation with add-on treatments and the sensitivity of the transmitted noise to the discrete stiffening of the sidewall panels.

82-591

General Aviation Propeller Noise Reduction -- Penalties and Potential

R.J. Klatte
Hamilton Standard Div., United Technologies, SAE Paper No. 810585

Key Words: Aircraft noise, Propeller noise, Noise reduction

Results of a study are reported in which the influence of noise reduction on weight and cost of propellers used in General Aviation aircraft was evaluated. Aircraft performance was not to be degraded by installation of the reduced noise propellers. Only propeller modifications were permitted. Engine modifications, such as introduction of a gearbox to reduce noise by reduction of RPM, were not permitted in the study. Major factors in noise reduction found promising in the study were optimization of performance by use of the best available airfoils, use of thin airfoils and a narrow elliptical tip blade planform, and increasing the number of blades consistent with maintaining aircraft performance.

82-592

Noise and Performance of General Aviation Aircraft: A Review of the MIT Study

G.P. Succi
Bolt, Beranek, and Newman, Inc., SAE Paper No. 810586

Key Words: Aircraft noise, Propeller noise, Noise reduction

The primary objective of the study was to explore the possibility of reducing noise from a general-aviation-type propeller without altering significantly its aerodynamic performance or the engine characteristics. Our study of this possibility involved aerodynamic and acoustic theory, design, construction, and wind tunnel testing of model propellers, design and manufacture of full-scale propellers, and, finally, flight tests.

82-593

Predicting Fatigue Crack Growth on Aircraft Structures

B.L. Smith and S.Y. Lee
The Boeing Co., Wichita, KS, SAE Paper No. 810593

Key Words: Aircraft, Fatigue life, Crack propagation

This paper presents a technical overview of the portion of fracture mechanics that deals with the theory and practice of predicting fatigue crack growth. The use of the stress intensity factor for predicting crack growth in various shaped structural members subjected to cyclic loading is introduced. Fracture toughness, crack growth rate, and crack growth retardation from overloads are also explained. Example problems are presented to enhance the clarity of explanations.

82-594

Qualitative Comparison of Calculated Turbulence Responses with Wind-Tunnel Measurements for a DC-10 Derivative Wing with an Active Control System

B. Perry
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83144, AIAA-81-0567, 13 pp (June 1981)
(Presented at the AIAA Dyn. Specialist Conf., Atlanta, April 8-11, 1981)
N81-26496

Key Words: Aircraft wings, Active control, Turbulence, Wind tunnel testing

Comparisons are presented of analytically predicted and experimental turbulence responses of a wind tunnel model of a DC-10 derivative wing equipped with an active control system. The active control system was designed for the purpose of flutter suppression, but it had additional benefit

of alleviating gust loads (wing bending moment) by about 25%. Comparisons of various wing responses are presented for variations in active control system parameters and tunnel speed.

82-595

Wing/Store Flutter with Nonlinear Pylon Stiffness

R.N. Desmarais and W.H. Reed, III

NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 18 (11), pp 984-987 (Nov 1981) 8 figs, 8 refs

Key Words: Aircraft, Wing stores, Struts, Flutter

Recent wind tunnel tests and analytical studies show that a store mounted on a pylon with low pitch stiffness provides substantial increase in flutter speed of fighter aircraft and reduces dependency of flutter on mass and inertia of the store. This concept, termed the decoupler pylon, utilizes a low-frequency control system to maintain pitch alignment of the store during maneuvers and changing flight conditions. Under rapidly changing transient loads, however, the alignment control system may allow the store to momentarily bottom against a relatively stiff backup structure in which case the pylon stiffness acts as a hardening nonlinear spring. Such structural nonlinearities are known to affect not only the flutter speed but also the basic behavior of the instability. This paper examines the influence of pylon stiffness nonlinearities on the flutter characteristics of wing-mounted external stores.

82-596

Wing/Store Flutter Suppression Investigation

T.E. Noll, L.J. Huttsell, and D.E. Cooley

Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH, J. Aircraft, 18 (11), pp 969-975 (Nov 1981) 18 figs, 1 table, 8 refs

Key Words: Aircraft, Wing stores, Flutter, Vibration control, Computer programs

The design, testing, and evaluation of active flutter suppression technology using a common wind tunnel model has been successfully completed by the U.S. and several European organizations. This paper emphasizes analytical predictions and presents test data for correlation. Several control laws were evaluated using the FASTOP computer program and a modified Nyquist criterion. Although the design and tests were conducted for a specific Mach number of 0.8, the analyses were performed at several Mach numbers to determine system effectiveness at off-design conditions.

82-597

Historical Development of Aircraft Flutter

I.E. Garrick and W.H. Reed, III

NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 18 (11), pp 897-912 (Nov 1981) 16 figs, 2 tables, 81 refs

Key Words: Aircraft, Flutter, Reviews

This paper presents a glimpse of problems arising in these areas and how they were attacked by aviation's pioneers and their successors up to about the mid-1950s. The emphasis is on tracing some conceptual developments relating to the understanding and prevention of flutter including some lessons learned along the way.

82-598

The Development of a Substitute Bird Model

J.S. Wilbeck and J.L. Rand

Div. of Engrg. Sci., Southwest Res. Inst., San Antonio, TX 78284, J. Engrg. Power, 103 (4), pp 725-730 (Oct 1981) 11 figs, 11 refs

Key Words: Aircraft engines, Blades, Bird strikes, Impact tests, Testing techniques

A comprehensive program was conducted to develop a model synthetic bird for use in engine blade impact testing. A hydrodynamic theory of the impact event was used to aid in determining the bird properties which had to be duplicated in the model. Of the two candidate models studied extensively, it was determined that a projectile fabricated from commercial gelatin impregnated with phenolic microballoons most nearly duplicated the impact loading history of real birds.

82-599

Aircraft Subfloor Response to Crash Loadings

H.D. Carden and R.J. Hayduk

NASA Langley Res. Ctr., Hampton, VA, SAE Paper No. 810614

Key Words: Aircraft, Crash research (aircraft), Energy absorption, Computer programs

Results are presented of an experimental and analytical study of the dynamic response to crash loadings of five different load-limiting subfloors for general aviation aircraft. These subfloors provide a high-strength structural floor

platform to retain the seats and a crushable zone to absorb energy and limit vertical loads.

82-600

Crashworthy Design Concepts for Airframe Structures of Light Aircraft

J.D. Cronkhite
Bell Helicopter Textron, Fort Worth, TX, SAE Paper No. 810613

Key Words: Aircraft, Crash research (aircraft), Crashworthiness, Energy absorption, Floors, Aircraft seats, Computer programs

Crashworthy concepts for airframe structures of general aviation aircraft have been investigated. Several crashworthy concepts of energy-absorbing lower floor structures were developed. Design support tests were conducted to determine the performance of these concepts. Five concepts were selected for fabrication as full-scale floor test sections. These floor test sections were designed to have a high strength structural platform, capable of attaching crashworthy, energy-absorbing seats, supported by an underfloor crush zone that provides energy absorption and controls the loads to this platform. The design of these floor sections was analytically verified with NASTRAN for the static conditions and with KRASH for the dynamic conditions.

82-601

Simulation of Aircraft Seat Response to a Crash Environment

J.W. Coltman, A.O. Bolukbasi, and D.H. Laananen
Simula Inc., SAE Paper No. 810612

Key Words: Aircraft, Aircraft seats, Crash research (aircraft), Crashworthiness, Computer programs

A new structural analysis method is being developed for incorporation into the seat/occupant model (Program SOM-LA), which is intended for use in evaluating the crashworthiness of aircraft seats. The analytical technique is described, and its capabilities are demonstrated in the simulation of the dynamic test of an actual aircraft seat. Computer simulation results are presented and compared with the test data.

82-602

Determination of Crash Test Pulses and Their Application to Aircraft Seat Analysis

E. Alfaro-Bou, M.S. Williams, and E.L. Fasanella
NASA Langley Res. Ctr., Hampton, VA, SAE Paper No. 810611

Key Words: Aircraft, Aircraft seats, Crash research (aircraft), Energy absorption, Experimental test data, Computer programs

Deceleration time histories (crash pulses) from a series of twelve light aircraft crash tests were analyzed to provide data for seat and airframe design for crashworthiness. A hybrid mathematical seat-occupant model was developed using the DYCAST nonlinear finite element computer code and was used to analyze a vertical drop test of the energy absorbing seat. Seat and occupant accelerations predicted by the DYCAST model compared quite favorably with experimental values.

82-603

US Army Crashworthiness Program

G.T. Singley, III
US Army Aviation Res. and Dev. Command, St. Louis, MO, SAE Paper No. 810615

Key Words: Aircraft, Crash research (aircraft), Crashworthiness

Results of the US Army R&D effort to improve aircraft crashworthiness are presented. Because this crashworthiness R&D program has spanned more than 20 years, this paper is only a summary; however, over the years scores of technical reports have been published documenting in detail the results of this program.

82-604

Flap-Lag-Torsional Dynamic Modelling of Rotor Blades in Hover and in Forward Flight, Including the Effect of Cubic Nonlinearities

M.R.M. Crespodasilva
Dept. of Aerospace Engrg. and Applied Mechanics, Cincinnati Univ., OH, Rept. No. NASA-CR-166194, ASD-81-6-1, 73 pp (July 1981)
N81-26116

Key Words: Helicopters, Propeller blades, Blades, Torsional response, Mathematical models

The differential equations of motion, and boundary conditions, describing the flap-lead/lag-torsional motion of a

flexible rotor blade with a precone angle and a variable pitch angle, which incorporates a pretwist, are derived via Hamilton's principle. The meaning of inextensionality is discussed.

82-605

Helicopter Fatigue Life Assessment

Advisory Group for Aerospace Res. and Dev., Neuilly-sur-Seine, France, Rept. No. AGARD-CP-297, 264 pp (Mar 1981) (Presented at the Meeting of the AGARD Structures and Materials Panel (51st), Aix-en-Provence, France, Sept 14-19, 1980)
AD-A101 017

Key Words: Helicopters, Fatigue life

The major objective of this meeting was to take a further step towards the collection of experience on the fatigue evaluation and substantiation of new helicopters. The meeting included surveys of current procedures and service experience, consideration of new concepts associated with the introduction of new technologies such as composite materials, new philosophies relevant to service damage and combat damage, and a review of testing techniques and methodologies for airframes and dynamic components. Finally, presentations were made on a European exercise aimed at the development of standardized fatigue load histories for helicopter rotors.

82-606

Flap-Lag-Torsional Dynamics of Extensional and Inextensional Rotor Blades in Hover and in Forward Flight

M.R.M. Crespodasilva
Dept. of Aerospace Engrg. and Applied Mechanics, Cincinnati Univ., OH, Rept. No. NASA-CR-164475, 3 pp (June 1981)
N81-26117

Key Words: Helicopters, Propeller blades, Blades, Torsional response

The formulation of differential equations of motion for both extensional and inextensional rotor blades, and the effect of cubic nonlinearities was examined. The developed differential equations are reduced to a set of three integro partial differential equations for a hingeless blade by eliminating the extension variable. Aerodynamic forces are modeled using Greenberg's extension of Theodorsen's strip theory. Equations of motion are expanded into polynomial nonlinearities to evaluate the motion of the system.

82-607

The Noise Characteristics of Inverted Velocity Profile Coannular Jets

A.M. Cargill and J.P. Duponchel
Rolls-Royce Ltd., P.O. Box 31, Derby, UK, J. Sound Vib., 78 (4), pp 495-517 (Oct 22, 1981) 23 figs, 25 refs

Key Words: Noise generation, Aircraft noise, Supersonic aircraft

Measurements have been made of the noise of inverted velocity profile coannular jets (outer greater than inner velocity), statically at model scale. It has been found that an annular jet has both jet mixing and shock-cell noise lower than a round jet and that this benefit is increased when flow is added to the center of the jet. Consideration of potential application shows that for a conventional turbofan with a large temperature differential between the streams, inverting the flows always gives lower noise but that this is rarely less than that of a single stream jet of the same thrust and mass flow. When both streams are hot and of a similar temperature, however, the inverted profile jet is always quieter.

82-608

The Effect of Proplets and Bi-Blades on the Performance and Noise of Propellers

J.P. Sullivan, L.K. Chang, and C.J. Miller
Purdue Univ., SAE Paper No. 810600

Key Words: Propeller noise

An analytical technique for predicting the aerodynamic performance of propellers with tip devices (proplets) using vortex lattice method shows that the ideal efficiency of a fixed diameter propeller can be improved by 1-5%. By suitable orientation and sweep of the proplet, the noise analysis method presented predicts that propellers with tip devices will have approximately the same noise as propellers without tip devices. Therefore proplets can be added to a fixed diameter propeller to improve the efficiency with no increase in noise or the noise may be reduced by decreasing the diameter with no loss in aerodynamic efficiency.

82-609

Helicopter Noise Exposure Level Data: Variations with Test Target, Indicated Airspeed, Distance, Main Rotor RPM and Takeoff Power

J.S. Newman

Office of Environ. and Energy, FAA, Washington, DC, Rept. No. FAA-AEE-80-34, 37 pp (July 10, 1980)
AD-A100 691

Key Words: Helicopter noise, Noise measurement

This report provides uncorrected noise exposure level data measured using an integrating sound level meter at a single measurement location during the recently completed, week long, FAA helicopter noise test. In addition to the measurements reported, primary acoustical measurements were conducted.

82-610
Model Helicopter Rotor Impulsive Noise
J.E. Hubbard, Jr. and W.L. Harris
Dept. of Aeron. and Astron., Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Sound Vib., 78 (3), pp 425-437 (Oct 8, 1981) 9 figs, 2 tables, 18 refs

Key Words: Helicopters, Rotors, Propeller blades

An investigation of helicopter rotor blade slap was performed on a model rotor. The effects of number of blades, blade pitch, advance ratio, and shaft angle on the generation and intensity of blade slap have been investigated. The effect of each parameter was determined by varying the parameter of interest while keeping the others constant. The rotor tip speeds of the tests performed in this study were limited to approximately Mach 0·4. The directivity associated with the blade slap signature was measured. The results of this investigation are based on a subjective definition of blade slap.

BIOLOGICAL SYSTEMS

HUMAN

82-611
Power Plant Noise Control
S.P. Nuspl and H.R. VanHandle
Babcock & Wilcox Co., Barberton, OH, ASME Paper No. 81-JPGC-Pwr-15

Key Words: Power plants (facilities), Industrial facilities, Human response, Noise generation

Equipment specifications often refer to Occupational Safety and Health Administration limits regarding allowable noise emissions. OSHA limits the exposure to noise, not its level. A study was undertaken to assess the extent of power plant employee exposure noise. Several criteria were used to determine the effect of noise on employees, the extent of noise control required, and its cost with particular emphasis on the steam generator and its auxiliaries.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 600, 602, 628)

82-612
Mechanical Design Handbook for Elastomers
M. Darlow and E. Zorzi
Mechanical Technology, Inc., Latham, NY, Rept. No. NASA-CR-3423, MTI-81TR5, 354 pp (June 1981)
N81-26461

Key Words: Elastomers, Design techniques, Rotating machinery

A comprehensive guide for the design of elastomer dampers for application in rotating machinery is presented. Theoretical discussions, a step by step procedure for the design of elastomer dampers, and detailed examples of actual elastomer damper applications are included. Dynamic and general physical properties of elastomers are discussed along with measurement techniques.

82-613
A New Method for Determining the Reaction of Rubber under Dynamic Stress (Eine neue Methode zur Bestimmung des Verhaltens von Gummi unter dynamischer Beanspruchung)
C. de Meersman and P. Vandoren
Direktor der Forschungs - und Entwicklungsabteilung von Bergougnan Benelux, Evergem/Belgien, Gummi, Asbestos, Kunststoffe, 34 (5), pp 280-284 (May 1981) 7 figs, 2 tables
(In German)

Key Words: Elastomers, Stiffness coefficients, Damping coefficients, Hysteretic damping

Dynamic properties are the main characteristics of rubber, e.g., stiffness, damping, and hysteresis. These properties are specially important for tires, shock absorbers, and vibration isolators. This paper gives a survey about the mentioned properties and the commonly used test methods. A new method is described by which the dynamic behavior of rubber can be measured quickly and exactly. The information about the single test results are independent of component shape.

82-614

Optimum Vibration Absorbers for Linear Damped Systems

S.E. Randall, D.M. Halsted, III, and D.L. Taylor

Sperry New Holland, New Holland, PA, J. Mech. Des., Trans. ASME, 103 (4), pp 908-913 (Oct 1981) 9 figs, 1 table, 5 refs

Key Words: Vibration absorption (equipment), Damped structures

This paper presents computational graphs that determine the optimal linear vibration absorber for linear damped primary systems. Considered as independent parameters are the main system damping ratio and the mass ratio examined over the range 0 to 0.50 and 0.01 to 0.40, respectively. The remaining nondimensional parameters were optimized using numerical methods based on minimum-maximum amplitude criteria. With independent parameters specified the computational graphs can be used to find the response amplitudes as well as the optimal absorber characteristics. This procedure is illustrated in a design example. A qualitative discussion of the sensitivity to parameter errors is presented.

82-615

Transition from a Non-Reverberant to a Reverberant Dynamic System

G. Maidanik and L.J. Maga

David W. Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD 20084, J. Sound Vib., 78 (3), pp 397-416 (Oct 8, 1981) 4 figs, 8 refs

Key Words: Isolation, Vibration isolation, Vibration damping, Reverberation

When a dynamic system is isolated from its environment it may become reverberant and inhibit the effectiveness of the isolation. The transition from a non-reverberant to a reverberant situation introduced by isolation is considered in this paper. An example is cited dealing with the escaping power from a one-dimensional dynamic system to its environment. Consideration is focused on an attempt to reduce the escaping power by isolating the dynamic system from its environment. A prescription for converting the formalism to a three-dimensional dynamic system (an enclosure) is proposed and developed. The use of coating as a means for providing isolation for an immersed enclosure is discussed.

82-616

Optimum Pulse Control of Flexible Structures

S.F. Masri, G.A. Bekey, and T.K. Caughey

J. Appl. Mech., Trans. ASME, 48 (3), pp 619-626 (Sept 1981) 11 figs, 26 refs

Key Words: Active vibration control, Stochastic processes, Earthquakes, Pulse excitation

A simple yet efficient active control method is presented for reducing the oscillations of distributed parameter systems subjected to arbitrary dynamic environments. Following determination that some specified response threshold has been exceeded, an open-loop control pulse is applied. The optimum pulse characteristics are determined analytically so as to minimize a non-negative cost function related to the structure energy. The proposed control method is shown to be reliable in consistently mitigating the response of realistic multidegree-of-freedom systems, whether linear or nonlinear, subject to arbitrary stochastic or deterministic excitation.

82-617

Fatigue Damage of the Locomotive Suspension Elements under Random Loading

D.S. Garivaltis, V.K. Garg, and A.F. D'Souza

Dynamics Res. Div., Association of American Railroads, Chicago, IL, J. Mech. Des., Trans. ASME, 103 (4), pp 871-880 (Oct 1981) 20 figs, 14 refs

Key Words: Suspension systems (vehicles), Locomotives, Random excitation, Fatigue life, Spectrum analysis

Spectral analysis techniques are employed to analyze the fatigue damage to the suspension of a six-axle locomotive on tangent track with vertical and lateral random track irregularities. The locomotive is represented by a thirty-nine degrees of freedom linear model. Spectral densities of forces and probability density functions for stress levels in suspension elements are generated. Using a modified definition of

transmissibility, the probability density functions of the output/input and mean square values of outputs are obtained for various stiffness ratios. A cumulative linear damage criterion based on Miner's theory is employed to predict fractional damage per operational second and mean life of the suspension elements. Operational stress cycles/sec. versus operational stress level are plotted for the suspension elements. These operational characteristics in conjunction with fatigue characteristics (S-N curve) can be effectively used as a tool for fatigue design.

82-618

Design Predictions for Noise Control in the Cryogenic National Transonic Facility

W.S. Lassiter

NASA Langley Res. Ctr., Hampton, VA, Noise Control Engrg., 17 (2), pp 76-84 (Sept-Oct 1981) 12 figs, 2 tables, 6 refs

Key Words: Acoustic linings, Noise reduction, Honeycomb structures, Fans

Two-layered perforated sheet/honeycomb core aluminum linings were designed to attenuate drive fan noise. A high-pressure cryogenic transonic wind tunnel that will use gaseous nitrogen at cryogenic temperatures to generate flows at full scale Reynolds numbers for current and planned aerospace vehicles is examined. A two layer perforated sheet honeycomb lining was designed to attenuate drive fan noise. A muffler consisting of trays filled with mineral wool and acting as an acoustical absorber was designed to attenuate noise from two throttling valves on the exhaust end of the tunnel. Fan silencers, an acoustical enclosure and a relatively large ejector exit area will be used to reduce fan and jet-mixing noise in the fan/ejector exhaust system of the tunnel. The fan/ejector system exhausts a high pressure nitrogen in the tunnel to the atmosphere through a 36.6 meter high exhaust stack and induces rapid mixing and warming of the cold gas with the atmosphere.

BLADES

(Also see Nos. 669)

82-619

Natural Frequencies of Rotating Bladed Discs Using Clamped-Free Blade Modes

S.J. Wildheim

Stal-laval Turbin AB, Finspong, Sweden, ASME Paper No. 81-DET-124

Key Words: Blades, Disks (shapes), Natural frequencies, Substructuring methods, Periodic structures

The problem of calculating the natural frequencies of a practical rotating bladed disc assembly is solved by use of a new dynamic substructuring method employing the free modes of the disc and the clamped-free modes of the blade. The bladed disc may have lacing-wires at any radius. The lacing-wire, or any other general elastic connection element, is assumed to extend around the whole circumference. Hence, the assembly fulfills the requirements for a circumferentially periodic structure. Centrifugal effects are included.

82-620

Eigenfrequencies and Mode Shapes of a Free-Standing, Twisted, Tapered and Rotating Blade with Respect to an Elastically Supported Root

H. Irretier and O. Mahrenholtz

Institut f. Mechanik, Universitat Hanover, W. Germany, ASME Paper No. 81-DET-125

Key Words: Blades, Timoshenko theory, Rotatory inertia effects, Transverse shear deformation effects, Variable cross section, Supports, Natural frequencies, Mode shapes

The natural bending vibrations of a free-standing, Timoshenko-beam-like blade are considered. The mathematical model describing the staggered blade includes the effects of rotation, twisting, tapering and of an elastic support at the blade root.

82-621

Determination of Vibration Amplitudes and Stresses Using the Holography Interference Techniques and Finite Element Method

Z.F. Fu

Shanghai Jao Tong Univ., China, ASME Paper No. 81-DET-132

Key Words: Blades, Compressor blades, Gas turbine blades, Amplitude measurement, Finite element technique, Holographic techniques

A new method which combines the holography interference technique with the finite element method for determining the distribution of vibration amplitudes and stresses of gas turbine compressor blades is presented in this paper. In comparison with the ordinary electrical strain gage method, the present method has the advantage that there is no limita-

tion to the number of measuring points and good results can be obtained even at high frequencies and modes.

82-622

Superhybrid Composite Blade Impact Studies

C.C. Chamis, R.F. Lark, and J.H. Sinclair

NASA Langley Res. Ctr., Cleveland, OH 44135, J. Engrg. Power, 103 (4), pp 731-738 (Oct 1981) 10 figs, 8 tables, 5 refs

Key Words: Blades, Composite materials, Fan blades, Impact tests

An investigation was conducted to determine the feasibility of superhybrid composite blades for meeting the mechanical design and impact resistance requirements of large fan blades for aircraft turbine engine applications. Two design concepts were evaluated: leading edge spar (TiCom) and center spar (TiCore), both with superhybrid composite shells. The investigation was both analytical and experimental. The results obtained show promise that superhybrid composites can be used to make light-weight, high-quality, large fan blades with good structural integrity. The blades tested successfully demonstrated their ability to meet steady-state operating conditions, overspeed, and small bird impact requirements.

82-623

Experimental Investigation on the Vibratory Characteristics of an Industrial Steam Turbine LP-Runner Blade with Lacing-Wire

J. Wachter, J. Jarosch, and R. Pfeiffer

Univ. Stuttgart, W. Germany, ASME Paper No. 81-DET-134

Key Words: Blades, Steam turbines, Natural frequencies, Resonant frequencies

By steam turbines with variable speed, the amplitudes of oscillation are usually reduced by different damping devices. This packet of runner blades leads to more complicated vibrations compared with the free standing blades. On a 4-MW original steam turbine, the behavior of vibration of the LP-blades under working conditions is researched. The influence of different types of coupling at natural-frequencies and resonance amplitudes is determined.

82-624

A Practical Approach to Systems Mode Analysis

P.W. Spence

General Electric Co., Lynn, MA, ASME Paper No. 81-DET-130

Key Words: Blades, Cantilever plates, Shrouds, Modal analysis

A simplified methodology is presented for the analysis of disc-blade-shroud assemblies to obtain system mode frequencies and stress and load distributions in the blades. The method uses the cantilever vibration characteristics of the blades with a traveling wave solution applied to the shroud boundary conditions.

82-625

Determination of Damping Values for Turbine Blades

W.G. Brown

Westinghouse Electric Corp., Lester, PA, ASME Paper No. 81-DET-131

Key Words: Blades, Turbine blades, Damping coefficients, Measurement techniques

The purpose of measuring damping values during a rotating test of a test row of turbine blades is to determine the system damping values of the blade which include material damping, frictional damping, and aerodynamic damping. Damping values can be determined by measuring the decay of the blade vibration upon removal of the excitation source or by measuring the sharpness of resonance during resonant blade vibration.

82-626

Investigation of Vibration of Shrouded Turbine Blades

J. Wachter and J. Wolfs

Univ. Stuttgart, W. Germany, ASME Paper No. 81-DET-129

Key Words: Blades, Turbine blades, Shrouds, Resonant frequencies, Normal modes, Mode shapes

The discussed investigation of parameters evidences the complexity of the vibration pattern of grouped blades. Some of the difficulties are mentioned, which arise from problems encountered in capturing the parameter functions and in computing the resonance frequencies and vibration modes of such configurations.

82-627

Vibrations of Twisted Rotating Blades

A.W. Leissa, J.K. Lee, and A.J. Wang

Ohio State Univ., Columbus, OH, ASME Paper No. 81-DET-127

Key Words: Blades, Turbomachinery blades, Shells, Ritz method

The literature dealing with vibrations of turbomachinery blades is voluminous, but the vast majority of it treats the blades as beams. In a previous paper a two-dimensional analytical procedure was developed and demonstrated on simple models of blades having camber. The procedure utilizes shallow shell theory along with the classical Ritz method for solving the vibration problem. Displacement functions are taken as algebraic polynomials. In the present paper the method is demonstrated on blade models having camber.

BEARINGS

(Also see No. 648)

82-628

The Vibration Isolating Properties of Uncentralized Squeeze-Film Damper Bearings Supporting a Flexible Rotor

R.A. Cookson and S.S. Kossa

School of Mech. Engrg., Cranfield Inst. of Tech., Cranfield, Bedford MK43 OAL, UK, J. Engrg. Power, 103 (4), pp 781-787 (Oct 1981) 10 figs, 1 table, 16 refs

Key Words: Bearings, Vibration isolation, Squeeze-film dampers, Squeeze-film bearings

The ability of an uncentralized squeeze-film damper bearing to inhibit the effects of vibration in a flexible rotor-bearing system, has been assessed in terms of nondimensional system parameters. This analytical approach has shown that a correctly designed squeeze-film damper bearing is a very effective means of reducing both the amplitude of motion of the rotor and the force transmitted to the bearing support structure. However, the analysis has also indicated that a poorly designed squeeze-film damper bearing can produce amplitudes and forces greater than those which would arise if the bearing support remained rigid. An experimental program has supported the validity of the above analytical technique by showing that the measured motion orbits of the journal and disk centers as the rotor passes through the critical speed, are very similar to those predicted theoretically. Also, the response curves for specific groups of system parameters show very similar trends in practice, to those which result from the analytical approach. Some indication of the ability of a squeeze-film damper bearing to reduce the effect of much greater unbalance than normal is also reported.

82-629

Studies on the Separating Oil Film (Elastohydrodynamic Oil Film Thickness) between the Inner Race and Rollers of a Roller Bearing

R.A.J. Ford and C.A. Foord

The Univ. of New South Wales, UK, Inst. of Engineers, Australia, Trans., Civil Engrg., 6 (2), pp 140-144 (July 1981) 6 figs, 1 table, 9 refs

Key Words: Bearings, Roller bearings, Lubrication, Fatigue life

The predictions of elastohydrodynamic lubrication theory suggest that a separating oil film can exist within the highly loaded contacts found in rolling element bearings and gears. This theory is being increasingly used in general engineering and it is important to know how reliable the predictions are for typical machine elements. This paper describes measurements of the thickness of the oil films between the inner race and rollers of a 63.5 mm (2½ inch) bore roller bearing at speeds up to 10,000 rpm, and compares the results with theoretical predictions. The predictions were found to be reasonable for normal conditions provided lubricant properties and operating conditions could be adequately specified. However, as data of the required accuracy is not always available it is important to appreciate the discrepancies which can arise from this source. Larger discrepancies were found for the highest speeds and are attributed to oil starvation at the contact and inlet shear heating.

GEARS

82-630

Theoretical and Experimental Analysis of Rattling Noise of Automotive Gearbox

T. Sakai, Y. Doi, K.-i. Yamamoto, T. Ogasawara, and M. Narita

Toyota Motor Co., Ltd., Japan, SAE Paper No. 810773

Key Words: Gear boxes, Automotive transmissions, Noise reduction

The rattling noise is most significant in many kinds of manual gearbox noises, which is generated at the idling stage of the

engine operation; this stage means that a car is at rest and the gearbox is in neutral. In this report, results of our simulation analysis and experimental studies of this rattling noise are introduced. From the simulation results, it was found possible to reduce this rattling noise by optimizing the torsional characteristics of the clutch plate. This result was verified by a laboratory experiment. Applying the result into the actual passenger car, we succeeded in decreasing the rattling noise to the acceptable level.

82-631

Research on Bending Strength Properties of Spur Gears with a Thin Rim

N. Arai, S. Harada, and T. Aida
Faculty of Engrg., Doshisha Univ., Kyoto, Japan,
Bull. JSME, 24 (195), pp 1642-1650 (Sept 1981) 23 figs, 1 table, 3 refs

Key Wrods: Gears, Gear teeth, Fatigue life, Flexural vibration, Finite element technique

In the present paper, the stresses and deformation at tooth and rim of gears with a thin rim caused by loading on tooth were examined by various experiments and finite element method. Moreover, the bending fatigue strength of gears with a thin rim was compared with that of solid gears.

82-632

The Sound Radiated from Gears (1st Report, Behaviour by Means of Acoustical Holography)

K. Umezawa and H. Houjoh
Res. Lab. of Precision Machinery and Electronics, Tokyo Inst. of Tech., 4259 Nagatsuta-machi, Midori-ku, Yokohama, Japan,
Bull. JSME, 24 (195), pp 1651-1657 (Sept 1981) 14 figs, 9 refs

Key Words: Gears, Sound waves, Natural frequencies

Acoustic behavior of a pair of gears, of 156 teeth with 2mm module, is investigated by means of acoustical holography which is capable of indicating the location and the intensity distribution of sound sources. Several improvements on the system have been performed for the practical measurements, such as applying two hologram planes and a complex hologram. The sound of tooth contact frequency (7.88kHz) is radiated strongly from the meshing point in the meshing direction with about 100 times greater power than that in the axial direction. Natural vibrations of the gear wheel occur in any conditions, and rotate together with the gear. The sound is produced according to the vibration from a spatially fixed viewpoint, thus the vibration causes two frequency sounds around the natural frequency instead of itself.

LINKAGES

(Also see No. 735)

82-633

On Predicting Vibrations in Realistically Proportioned Linkage Mechanisms

R.S. Haines
Dept. of Mech. Engrg., Univ. of Newcastle upon Tyne, Newcastle, UK,
J. Mech. Des., Trans. ASME, 103 (4), pp 706-711 (Oct 1981) 2 figs, 10 refs

Key Words: Linkages

The paper explores the proposition that deflections in high-speed linkage mechanisms of 'realistic' proportions may be estimated as if the rigid-body inertial loads were applied statically. Some practical limitations are examined in detail, and the paper considers the circumstances in which the adoption of relatively more flexible links may become normal practice.

82-634

Stress Fluctuation in High Speed Mechanisms

A.T. Yang, G.R. Pennock, and L.M. Hsia
Dept. of Mech. Engrg., Univ. of California, Davis, CA 95616,
J. Mech. Des., Trans. ASME, 103 (4), pp 736-742 (Oct 1981) 2 figs, 2 tables, 20 refs

Key Words: Slider crank mechanisms, Linkages, Harmonic analysis

In this paper analytical expressions are derived which describe the nature of the stress fluctuation induced in a member of a high speed mechanism. For design applications a harmonic analysis of the stress fluctuation is presented and the results are expressed in a non-dimensional form. For illustrative purposes, the analysis is centered on the coupler link of the well-known slider-crank mechanism.

82-635

The Simultaneous Analytical Synthesis of Mass and Spring Elements in Planar Mechanisms

J.N. Griffin and G.K. Matthew
Dept. of Mech. Engrg., Univ. of Florida, Gainesville, FL, J. Mech. Des., Trans. ASME, 103 (4), pp 758-763 (Oct 1981) 4 figs, 2 tables, 15 refs

Key Words: Slider crank mechanism, Mass coefficients, Spring constants, Structural synthesis

The potential energy storage of linear springs and the kinetic energy storage of a body in motion are associated with the nonlinear motion of planar mechanisms to provide precision point control of desired dynamic phenomena. The work is closely analogous to synthesis of constraint links for pure kinematics problems.

SEALS

82-636

Avoid Problems with Steam Turbine Carbon Ring Seals

S.W. Mazlack
Amoco Oil Co., Chicago, IL, Hydrocarbon Processing, 8 (9), pp 143-145 (Aug 1981) 2 figs

Key Words: Steam turbines, Seals, Proximity probes, Vibration measurement

A commonly experienced problem is excessive steam leakage along the shaft of a steam turbine out its gland housing, or "seal stuffing box." Where carbon ring seals are used to prevent leakage of steam from, or ingress of air into the turbine through its seal casing, premature leakage usually is caused by improper or no break-in of the carbon rings. An effective break-in method using non-contacting eddy current vibration probes and a discussion of the basic factors affecting break-in is presented.

CAMS

82-637

Resonances and Instabilities in Dynamic Systems Incorporating a Cam

D.L. Cronin and G.A. LaBouff
Dept. of Mech. and Aerospace Engrg., Univ. of Missouri-Rolla, Rolla, MO, J. Mech. Des., Trans. ASME, 103 (4), pp 914-921 (Oct 1981) 10 figs, 7 refs

Key Words: Cams, Resonant frequencies, Stability

A model consisting of two oscillators coupled through a kinematic constraint is employed in this paper to investigate resonances and instabilities in dynamic systems incorporating a cam. Examination of linearized motion equations exposes parameters governing system behavior. Explored using numerical integration, Floquet analysis, and approximate methods are coupling-induced modification of conventionally-predicted resonant behavior, and two categories of subharmonic and superharmonic instability. Approximate methods described in this paper for predicting resonances and instabilities appear to function reliably and offer the potential for reduced analysis cost.

82-638

Residual Vibration Criteria Applied to Multiple Degree of Freedom Cam Followers

J.L. Wiederrich
FMC Corp., Central Engrg. Labs., Santa Clara, CA, J. Mech. Des., Trans. ASME, 103 (4), pp 702-705 (Oct 1981) 3 figs, 1 table, 10 refs

Key Words: Cam followers, Multidegree of freedom systems, Modal analysis

The vibration characteristics of a cam motion are generally presented by plotting the single degree of freedom residual vibration as a function of normalized operating speed. In this paper it is shown that by applying the methods of modal analysis, these residual vibration characteristics can be extended to the characterization of the vibration response of a multiple degree of freedom cam follower system.

82-639

Assessment of the Dynamic Quality of a Class of Dwell-Rise-Dwell Cams

F.Y. Chen
Dept. of Mech. Engrg., Ohio Univ., Athens, OH 45701, J. Mech. Des., Trans. ASME, 103 (4), pp 793-802 (Oct 1981) 8 figs, 1 table, 24 refs

Key Words: Cams, Cam followers, Dynamic response

A number of new cam profiles of the dwell-rise-dwell type have been proposed by different researchers in the past two decades. They were claimed as efficient cam curves suitable for high-speed applications. This paper re-examines these profiles with regard to the important vibrational response characteristics when they are applied as motion excitations

to a cam-and-follower system. The severity of the dynamic response of the cam follower to the motion excitation of a cam will be measured by a dimensionless quantity known as the normalized acceleration amplification factor. A simplified response envelop for the residual vibration of NAAF versus the fundamental period is constructed so that an assessment of the merit of any given cam profile can be made qualitatively and quantitatively.

STRUCTURAL COMPONENTS

CABLES

82-640

Calculation of Catenary Vibration by Means of Frequency-Dependent Finite Elements (Zur Berechnung von Fahrleitungsschwingungen mit Hilfe frequenzabhängiger finiter Elemente)

M. Link
Fachgebiet Leichtbau, Univ. Gesamthochschule Kassel Wilhelmshoher Allee 71, D-3500 Kassel, Bundesrepublik Deutschland, Ing. Arch., 51 (1/2), pp 45-60 (1981) 14 figs, 2 tables, 8 refs
(In German)

Key Words: Catenaries, Pantographs, Natural frequencies, Finite element technique

The coupled analysis of the dynamic behavior of an overhead catenary with a pantograph moving at high speed requires the representation of the catenary natural modes up to very high frequencies. This requirement hampers the economic use of commercial finite-element-programs, because too many degrees of freedom are necessary in the finite-element-model of a multi-span catenary to represent the highest natural frequencies with the required accuracy. The analytical solution of the string differential equation is used in the paper to derive frequency dependent element matrices, in order to combine the finite-element modeling technique with the accuracy of the analytical solution. Thus element partitioning is only governed by geometrical and physical requirements. The paper ends with a comparative analysis of a two-span catenary which was tested by British Railways.

82-641

Vibrations of Slack Cables with Discrete Masses

F. Rosenthal
Naval Res. Lab., Washington, DC 20375, J. Sound Vib., 78 (4), pp 573-583 (Oct 22, 1981) 1 fig, 3 tables, 9 refs

Key Words: Cables, Natural frequencies, Mode shapes

This paper describes a new method for obtaining the natural frequencies and mode shapes of arbitrarily slack cables which may contain concentrated masses as well as distributed mass and tensile stiffness. The method of imaginary reactions is used to perform the static calculation and Stodola's method is applied to do the dynamics. Integral formulas for the required influence functions appropriate to both fixed-fixed and fixed-forced boundary conditions are included. Solutions to sample problems, obtained with a program implemented on Naval Research Laboratory's Advanced Scientific Computer, are presented. The efficiency of this method is believed to exceed that of available finite element programs when the required number of integration intervals is large: that is, when numerous masses are present and/or high order modes are required.

82-642

Guy-Cable Design and Damping for Vertical-Axis Wind Turbines

T.G. Carne
Sandia Natl. Lab., Albuquerque, NM, 35 pp (May 1981)
SAND-80-2669

Key Words: Cables, Towers, Vibration damping, Turbines, Wind turbines

Guy cables are frequently used to support vertical axis wind turbines since guying the turbine reduces some of the structural requirements on the tower. The guys must be designed to provide both the required strength and the required stiffness at the top of the turbine. The axial load which the guys apply to the tower, bearings, and foundations is an undesirable consequence of using guys to support the turbine. Limiting the axial load so that it does not significantly affect the cost of the turbine is an important objective of the cable design. The lateral vibration of the cables is another feature of the cable design which needs to be considered. These aspects of the cable design are discussed in this paper, and a technique for damping cable vibrations is mathematically analyzed and demonstrated with experimental data.

BARS AND RODS

82-643

Dispersion of Elastic Waves in Bars with Polygonal Cross Section

K. Nagaya

Dept. of Mech. Engrg., Faculty of Engrg., Gunma Univ., Kiryu, Gunma, Japan, J. Acoust. Soc. Amer., 70 (3), pp 763-770 (Sept 1981) 2 figs, 4 tables, 21 refs

Key Words: Bars, Membranes (structural members), Plates, Harmonic waves, Wave propagation

This paper studies harmonic wave propagation in an infinite elastic bar of polygonal cross section with stress-free surface. The frequency equations for longitudinal, torsional, and flexural waves have been obtained by making use of the Fourier expansion collocation method which has been developed by the author on the vibration and dynamic response problems of membranes and plates.

BEAMS

(Also see Nos. 668, 682, 707)

82-644

Response of Periodic Systems to a Moving Load

L. Jezequel

Dept. of Mech. Engrg., Ecole Centrale de Lyon, 36 route de Dardilly, Ecully, 69130, France, J. Appl. Mech., Trans. ASME, 48 (3), pp 613-618 (Sept 1981) 7 figs, 34 refs

Key Words: Periodic structures, Moving loads, Beams, Critical speeds, Winkler foundations

The motion of a beam or a plate resting on an elastic foundation and subjected to a moving load has been studied by numerous authors. But the extension of these studies to the case of periodic structures is difficult. In this paper, a method allowing the calculation at low numerical cost of periodically supported beams subjected to a moving force, is proposed. The interpretation of this method on the basis of the free-wave propagation equations in periodic structures has led to the definition of the predominant, so-called "primary," critical speeds. Individual examples were used to test the method. It was also possible to define the limits of a Winkler continuous model in representing the support reactions.

82-645

A Linearly Tapered Beam Finite Element Incorporating Shear Deformation and Rotary Inertia for Vibration Analysis

C.W.S. To

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 78 (4), pp 475-484 (Oct 22, 1981) 4 figs, 1 table, 12 refs

Key Words: Beams, Variable cross section, Finite element technique, Transverse shear deformation effects, Rotatory inertia effects

Explicit expressions for the element mass and stiffness matrices of a linearly tapered beam finite element including shear deformation and rotary inertia are given in this paper. The element cross section rotation is assumed to be a sum of the slope of the transverse displacement and the shear. The cross-sectional dimensions vary linearly along the length of the element. Two series of eigenvalue solutions have been carried out. One was performed with various taper ratios in order to provide a comparison with classical cases. The other was used to determine the aspect ratio effect on the eigenvalues of thin-walled tapered cantilever beam structures. The approach presented is straightforward, and allows comparisons to be made with other explicit solutions without recourse to numerical examples.

82-646

Steady Motion of an Elastic Beam Across a Rigid Step

G.G. Adams and H. Manor

Dept. of Mech. Engrg., Northeastern Univ., Boston, MA, J. Appl. Mech., Trans. ASME, 48 (3), pp 606-612 (Sept 1981) 9 figs, 7 refs

Key Words: Beams, Bernoulli-Euler method, Timoshenko theory, Mode shapes, Foundations

An infinite elastic beam moves at constant speed across a frictionless rigid step. Steady-state solutions are obtained in closed form using both Euler-Bernoulli and Timoshenko beam models. With step height and speed as parameters, the noncontact regions, mode shapes, and foundation reactions are determined. The results show interesting qualitative as well as quantitative differences between the behavior of the Euler-Bernoulli and Timoshenko beams.

82-647

Unsteady Response Due to Support Fracture of a Multispan Vibrating Beam

Y. Hirano and K. Nagaya

Dept. of Mech. Engrg., Yamagata Univ., Yonezawa, Japan, J. Sound Vib., 77 (4), pp 513-525 (Aug 22, 1981) 4 figs, 4 tables, 10 refs

Key Words: Beams, Elastic foundations, Fracture properties

The unsteady response to sudden support fracture of a multispan vibrating beam on elastic supports is analyzed. For the initial conditions the exact expressions of the deflection and the velocity just before the fracture of the support are applied without using assumptions. The exact solution of the beam's equation of motion for the dynamic response is derived by use of a technique previously developed by the authors. Numerical calculations are carried out for two-span, three-span and five-span beams with the same span length subjected to sinusoidal concentrated loads.

CYLINDERS

82-648

Noise Due to Resonant Excitation of a Rotating Cylinder

J.P. Ries and P.G. Witherell

E.I. DuPont de Nemours & Co., Inc., Wilmington, DE, ASME Paper No. 81-DET-98

Key Words: Rolling friction, Cylinders, Cylindrical shells, Resonant frequencies, Natural frequencies, Noise generation

Machinery noise generated by rolling contact is radiated into the environment from the outer surfaces of the rotating elements. At certain rotational speeds, excessive noise is generated owing to resonant excitation within the shell of the rolling elements. Predicting the conditions under which this noise will occur is complicated by dynamic effects due to rotation. Analysis of the vibration response of a hollow, rotating cylinder demonstrated that rotational effects significantly change the natural frequencies.

FRAMES AND ARCHES

82-649

The Effects of Initial Thrust and Elastic Foundation on the Vibration Frequencies of a Shallow Arch

R.H. Plaut and E.R. Johnson

Dept. of Civil Engrg., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 78 (4), pp 565-571 (Oct 22, 1981) 3 figs, 9 refs

Key Words: Arches, Elastic foundations

A shallow elastic arch subjected to a static load is considered. Plots of load magnitude versus the squares of the vibration frequencies (i.e., characteristic curves) have been obtained previously. Here, the effects of initial thrust and elastic foundation on the characteristic curves are investigated. For simplicity, results are derived for an arch with pinned ends and a sinusoidal initial shape, and the static load is assumed to have a sinusoidal distribution.

MEMBRANES, FILMS, AND WEBS

(See Nos. 643, 666)

PANELS

82-650

Acoustoelasticity of a Damped Sandwich Panel Backed by a Cavity

S. Narayanan and R.L. Shanbhag

Dept. of Appl. Mechanics, Indian Inst. of Tech., Madras, 600036, India, J. Sound Vib., 78 (4), pp 453-473 (Oct 22, 1981) 9 figs, 7 tables, 15 refs

Key Words: Panels, Sandwich structures, Panel-cavity response, Sound transmission

The problem of sound transmission and structural response of a sandwich panel backed by a cavity is analyzed in an acoustoelastic formulation. The panel consists of two elastic face layers with a constrained viscoelastic damping layer. The cavity pressure is expanded in terms of cavity normal modes and the structural response is expanded in terms of forced damped normal modes. The problem is set in matrix format in terms of cavity pressure coefficients and structural generalized co-ordinates. A matrix inversion scheme is proposed and used for the solution.

82-651

Finite-Element Nonlinear Transient Response Computer Programs PLATE 1 and CIVM-PLATE 1 for the Analysis of Panels Subjected to Impulse or Impact Loads

R.L. Spilker, E.A. Witmer, S.E. French, and J.J.A. Rodal

Aeroelastic and Structures Res. Lab., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. NASA-CR-165215, ASRL-TR-154-14, 497 pp (Sept 1980) N81-26491

Key Words: Computer programs, Panels, Transient response, Impact response

Two computer programs are described for predicting the transient large deflection elastic viscoplastic responses of thin single layer, initially flat unstiffened or integrally stiffened, Kirchhoff-Love ductile metal panels. The PLATE 1 program pertains to structural responses produced by prescribed externally applied transient loading or prescribed initial velocity distributions. The collision imparted velocity method PLATE 1 program concerns structural responses produced by impact of an idealized nondeformable fragment. Finite elements are used to represent the structure in both programs. Strain hardening and strain rate effects of initially isotropic material are considered.

82-652

Reexamination of Stability of a Two-Dimensional Finite Panel Exposed to an Incompressible Flow

Y. Matsuzaki

Natl. Aerospace Lab., Jindaiji, Chofu, Tokyo, Japan, J. Appl. Mech., Trans. ASME, 48 (3), pp 472-478 (Sept 1981) 4 figs, 13 refs

Key Words: Panels, Flutter, Fluid-induced excitation

Stability of a flat or buckled panel exposed to an incompressible flow has been reanalyzed as the analyses on this problem by other investigators have errors in the fluid forces used. The deflection of the panel in an oscillatory motion is assumed in such a way that there occurs no change in the fluid volume in a control surface enclosing the panel. The nonlinear equation of motion of the panel on a continuous elastic spring is solved by using the Galerkin method and the generalized fluid forces which are derived in the author's previous paper. The stability of the flat and buckled configuration in static equilibrium is examined against small disturbances. Existence of the limit cycle oscillation is studied by applying the harmonic balance method. Numerical results are compared with those of the analysis on a two-dimensional finite elastic channel conveying an almost incompressible flow.

82-653

Transient Vibrations of Elastic Panels Due to the Impact of Shock Waves

J.R. Coleby and J. Mazumdar

Dept. of Appl. Math., The Univ. of Adelaide, South Australia, Australia, J. Sound Vib., 77 (4), pp 481-494 (Aug 22, 1981) 6 figs, 3 tables, 14 refs

Key Words: Panels, Shock waves, Transient response

The dynamic response of elastic panels subjected to pressure loadings by shock waves is investigated. Accurate approximate solutions for the time-history response (displacement as well as strain) are obtained for the cases of both simply supported and completely clamped panels of various polygonal boundary shapes. The transient behavior is discussed by using the isoamplitude contour lines method in conjunction with the normal mode method. The analyses derived here have technical applications in the estimation of window, wall panel or flat roof response to a sonic boom or to explosion blast waves. All details are explained by graphs. Some comparison is made with previously obtained results whereever available.

PLATES

(Also see Nos. 643, 682)

82-654

Random Vibration of an Annular Plate

S. Chonan

Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 78 (1), pp 1-13 (Sept 8, 1981) 7 figs, 3 refs

Key Words: Plates, Annular plates, Random vibration

The mean-square displacement and moment of an annular plate excited by a distribution of stationary random forces that are uncorrelated in space are studied analytically. The plate is elastically restrained against translation and rotation along the edges. In addition the plate is subjected to a uniform initial tension or compression and is mounted on an elastic foundation. Numerical results are presented for annular plates with free outside and elastically restrained inside edges when the temporal correlation function of the excitation possesses an exponential decay. It is concluded that the mean-square displacement is maximum at the outside edge, while the mean-square moment takes on a maximum value along the inner boundary of the plate regardless of the constraint stiffness of the edge, the intensity of the initial stress and the stiffness of the foundation.

82-655

Non-Linear Vibration of Circular Plates with Transverse Shear and Rotatory Inertia

C.Y. Chia and M. Sathyamoorthy

Dept. of Civil Engrg., The Univ. of Calgary, Calgary, Alberta, Canada T2N 1N4, J. Sound Vib., 78 (1), pp 131-137 (Sept 8, 1981) 6 figs, 8 refs

Key Words: Plates, Circular plates, Flexural vibration, Rotatory inertia effects, Transverse shear deformation effects

This study is an analytical investigation of large amplitude flexural vibrations of clamped circular plates with stress-free and immovable edges. The effects of transverse shear deformation and rotatory inertia are included in the governing equations. Solutions are formulated on the basis of Galerkin's method and calculated by using the Runge-Kutta numerical procedure. An excellent agreement is found between the present results and those reported earlier for non-linear static and dynamic cases. Numerical results indicate that the effects of transverse shear deformation and rotatory inertia are usually negligible in the non-linear dynamic analysis of circular plates, but can be significant for moderately thick plates with a radius-to-thickness ratio less than 10.

82-656

A Note on Transverse Vibrations of Stiffened Rectangular Plates with Edges Elastically Restrained Against Rotation

P.A.A. Laura and R.H. Gutierrez

Inst. of Appl. Mechanics, 8111 Puerto Belgrano Naval Base, Argentina, J. Sound Vib., 78 (1), pp 139-144 (Sept 8, 1981) 5 figs, 3 refs

Key Words: Plates, Rectangular plates, Stiffened plates, Fundamental frequency

This note deals with the determination of the fundamental frequency of vibration of rectangular plates with edges elastically restrained against rotation. The plate is reinforced by a single integral stiffener placed along one of its center lines. It is assumed that the value of the parameter stiffener depth/plate thickness is "moderate."

82-657

Fundamental Frequency of Vibrations of a Rectangular Plate with a Free, Straight Corner Cut-Out

P.A.A. Laura, P. Verniere de Irassar, and L. Ercoli

Inst. of Appl. Mechanics, Puerto Belgrano Naval Base, Argentina, J. Sound Vib., 78 (4), pp 489-493 (Oct 22, 1981) 3 figs, 1 table, 7 refs

Key Words: Plates, Rectangular plates, Fundamental frequency

An approximate solution of the problem is obtained by using the Ritz method. It is assumed that the edges of the rectangular plate are elastically restrained against rotation and that translation is prevented. The displacement amplitude is approximated in terms of a polynomial co-ordinate function which identically satisfies the prescribed boundary conditions along the orthogonal edges but not along the corner cut-out. The analytical predictions are in reasonably good agreement with experimental results performed on a rigidly clamped square plate.

82-658

Upper and Lower Bounds for Frequencies of Trapezoidal and Triangular Plates

J.R. Kuttler and V.G. Sigillito

Appl. Phys. Lab., The Johns Hopkins Univ., Milton S. Eisenhower Res. Ctr., Laurel, MD 20810, J. Sound Vib., 78 (4), pp 585-590 (Oct 22, 1981) 2 figs, 4 tables, 11 refs

Key Words: Plates, Triangular bodies, Trapezoidal bodies

Upper and lower bounds are given for the two lowest frequencies of vibration of clamped trapezoidal and triangular plates. It is believed that this is the first time that rigorous bounds have been calculated for the vibrational frequencies of plates of these shapes.

82-659

Plate Vibration Research, 1976-1980: Complicating Effects

A.W. Leissa

Boyd Lab., Ohio State Univ., 155 W. Woodruff, Columbus, OH 43210, Shock Vib. Dig., 13 (10), pp 19-36 (Oct 1981) 205 refs

Key Words: Plates, Flexural vibration, Anisotropy, Variable cross section, Transverse shear deformation effects, Rotatory inertia effects, Fluid-induced excitation, Reviews

This paper is the second of two summarizing recent research in free, transverse vibrations of plates. The first one dealt with problems governed by the classical theory of plates. The present one considers complicating effects such as anisotropy, inplane force, variable thickness, surrounding media (e.g., air or water), large (nonlinear) transverse displacements, shear deformation, rotary inertia and nonhomogeneity.

82-660

Diffraction of Elastic Waves by a Surface Crack on a Plate

T. Kundu and A.K. Mal

Dept. of Mechanics and Structures, Univ. of California, Los Angeles, CA, J. Appl. Mech., Trans. ASME, 48 (3), pp 570-576 (Sept 1981) 8 figs, 1 table, 14 refs

Key Words: Plates, Cracked media, Elastic waves, Wave diffraction

The interaction of time harmonic elastic waves with an edge crack in a plate is studied. The crack is assumed to be normal to the plate surface and its depth small compared to plate thickness. Only plane strain deformations are considered. The incident waves are assumed to be either plane body waves (compressional (P) or inplane shear (SV) of arbitrary angle of propagation or surface Rayleigh waves propagating at right angles to the crack. For each incident wave type the complete high frequency diffracted field on the plate surface is calculated. Solution is obtained by the application of an asymptotic theory of diffraction. Application to ultrasonic inspection techniques is indicated.

82-661

Experimental Determination of Modal Densities and Loss Factors of Flat Plates and Cylinders

B.L. Clarkson and R.J. Pope

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 77 (4), pp 535-549 (Aug 22, 1981) 16 figs, 8 refs

Key Words: Plates, Cylinders, Modal analysis, Loss factor

Two of the important parameters which describe the dynamic characteristics of structures are the modal density and loss factor. Analytical expressions are available for the modal density of simple structures and approximate results have been suggested for built up structures. There are no analytical results for the loss factor of structures. The purpose of the work described in this paper is the development of an indirect experimental method for the determination of these two parameters. The first step is to estimate the modal density of simple structures such as a plate and a cylinder for which analytical results are available. Good agreement is shown to exist in these cases. The longer term objective is to develop the method for application to structures for which there is no analytical result available. The indirect results for loss factors are compared with estimates obtained from decay tests.

82-662

A Note on Edge Noise Theories

R.K. Amiet

United Technologies Res. Ctr., East Hartford, CT 06108, J. Sound Vib., 78 (4), pp 485-488 (Oct 22, 1981) 7 refs

Key Words: Plates, Fluid-induced excitation, Noise generation

A problem recently examined is that of the noise produced by a semi-infinite flat plate immersed in a jet flow of finite extent with the observer located outside the flow in a stationary fluid. The expressions derived therein for leading and trailing edge noise are here compared to those of the author for the somewhat different case where the flow extends to infinity, so that the observer is immersed in the moving fluid with no shear layer between the source and observer. The expressions for the directivity are found to be identical in the high frequency limit if account is taken of the shear layer refraction which is present in the former case but not the latter. At low frequency the problems are fundamentally different because of sound reflection from the shear layer.

82-663

The Influence of a Bubble Layer on Sound Radiation from a Plate

Y.L. Sinai

Dept. of Appl. Math. Studies, Univ. of Leeds, Leeds LS2 9JT, UK, J. Sound Vib., 78 (4), pp 531-553 (Oct 22, 1981) 5 figs, 1 table, 15 refs

Key Words: Plates, Bubble dynamics, Fluid-induced excitation, Sound waves, Wave propagation

An asymptotic far field analysis has been carried out on the integral representing the field transmitted to the pure fluid by a line-forced, fluid-loaded, infinite thin elastic plate in the presence of a bubble layer. The results indicate that the expected attenuation does indeed exist over wide ranges of frequency; however, at high and low frequencies the presence of the layer can result in an increase of radiated acoustic power, for prescribed forcing amplitude. The paper also outlines, qualitatively, the fields existing in and near the layer. The results will be of interest not only to acousticians and naval architects but also to any scientists or engineers concerned with general two-phase influences on the dynamics of fluid-loaded structures.

82-664

Acoustic Radiation from Fluid-Loaded Elastic Plates I. Antisymmetric Modes

B.L. Woolley

Naval Ocean Systems Ctr., San Diego, CA 92152, J. Acoust. Soc. Amer., 70 (3), pp 771-781 (Sept 1981) 8 figs, 12 refs

Key Words: Plates, Fluid-induced excitation

The Timoshenko-Mindlin plate equation of motion is modified in order to simultaneously specify the precise cutoff and asymptotic behavior of both antisymmetric modes of plate vibration described by it. A mathematical method for extending equations of motion to include higher order antisymmetric modes is presented. This method is illustrated by the development of an equation of motion for the first four antisymmetric modes of plate vibration.

82-665

Additional Solutions to the Free Bending Waves of a Fluid Loaded Thick Plate

M. Pierucci

Dept. of Aerospace Engrg. and Engrg. Mechanics, San Diego State Univ., San Diego, CA 92182, J. Acoust. Soc. Amer., 70 (3), pp 866-869 (Sept 1981) 6 figs, 6 refs

Key Words: Plates, Fluid-induced excitation, Flexural vibration

Different researchers over the last few years have presented results showing how the root loci of the free bending waves of a fluid loaded infinite plate vary as a function of frequency and fluid properties. The purpose of this paper is to present other possible solutions of this paper and to indicate how the different modes can, for few typical cases of interest, shift from one Riemann sheet to the other.

82-666

Free Vibration of Membranes and Plates with Four Curved Edges

T. Irie, G. Yamada, and K. Yoda

Dept. of Mech. Engrg., Faculty of Engrg., Hokkaido Univ., Sapporo, 060 Japan, J. Acoust. Soc. Amer., 70 (4), pp 1083-1088 (Oct 1981) 7 figs, 3 tables, 21 refs

Key Words: Membranes (structural members), Plates, Free vibration, Natural frequencies, Mode shapes

An analysis is presented for the free vibration of membranes and plates with four curved edges. For this purpose, a membrane or a plate is transformed into a square membrane or a square plate, respectively, of unit length by the transformation of variables. The transverse deflection of transformed membrane or plate is expressed in a series of the deflection functions of strings (strips of membrane) or of beams parallel to the edges of the square, and the frequency equations are derived by the Ritz method. The elements of the equations are calculated by numerical integration, since they cannot be expressed analytically. By the application of the method, the natural frequencies and the mode shapes are calculated numerically up to higher modes for the membranes and plates symmetrical with respect to the center lines.

82-667

Finite-Element Modeling of Layered, Anisotropic Composite Plates and Shells: A Review of Recent Research

J.N. Reddy

Dept. of Engrg. Sci. and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Shock Vib. Dig., 13 (12), pp 3-12 (Dec 1981) 120 refs

Key Words: Plates, Shells, Reviews, Composite structures, Finite element technique

This paper reviews finite element papers published in the open literature on the static bending and free vibration of layered, anisotropic, and composite plates and shells. The paper also contains a literature review of large-deflection bending and large-amplitude free oscillations of layered composite plates and shells. Non-finite element literature is also cited for continuity of the discussion.

SHELLS

(Also see Nos. 627, 661, 667, 671, 682)

82-668

Finite Strip Analysis of Singly Curved Skin-Stringer Structures

M. Petyt and C.C. Fleischer

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 77 (4), pp 561-571 (Aug 22, 1981) 5 figs, 2 tables, 17 refs

Key Words: Shells, Beams, Skin-stringer method, Finite strip method, Natural frequencies, Mode shapes

A rectangular, singly curved, finite strip shell element and a compatible thin walled, open section beam element are

derived. Convergence studies for freely supported and clamped, singly curved, rectangular shells show that only a few strips need be used to obtain good accuracy. Both five bay and 15 bay skin-stringer structures are analyzed. The results show that the frequencies and mode shapes obtained agree closely with transfer matrix results and experimental measurements.

82-669

Vibrations of Cantilevered Shallow Cylindrical Shells of Rectangular Planform

A.W. Leissa, J.K. Lee, and A.J. Wang
Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH 43210, J. Sound Vib., 78 (3), pp 311-328 (Oct 8, 1981) 3 figs, 8 tables, 25 refs

Key Words: Shells, Cylindrical shells, Blades, Turbomachinery blades

A cantilevered, shallow shell of circular cylindrical curvature and rectangular planform exhibits free vibration behavior which differs considerably from that of a cantilevered beam or of a flat plate. Some numerical results can be found for the problem in the previously published literature, mainly obtained by using various finite element methods. The present paper is the first definitive study of the problem, presenting accurate non-dimensional frequency parameters for wide ranges of aspect ratio, shallowness ratio and thickness ratio. The analysis is based upon shallow shell theory. Numerical results are obtained by using the Ritz method, with algebraic polynomial trial functions for the displacements. Convergence is investigated, with attention being given both to the number of terms taken for each co-ordinate direction and for each of the three components of displacement. Accuracy of the results is also established by comparison with finite element results for shallow shells and with other accurate flat plate solutions.

82-670

A Seismic Response Analysis of a Cylindrical Liquid Storage Tank Including the Effect of Sloshing

K. Fujita
Takasago Technical Inst., Technical Headquarters, Mitsubishi Heavy Industries, Ltd., Takasago, Hyogo Pref., 676, Japan, Bull. JSME, 24 (195), pp 1634-1641 (Sept 1981) 5 figs, 3 tables, 13 refs

Key Words: Tanks (containers), Storage tanks, Earthquake response, Sloshing

A seismic response analysis method for a cylindrical liquid storage tank subjected to a horizontal earthquake is presented in this paper. The kinetic and strain energies of an empty tank shell are estimated assuming it as an axisymmetric shell. The virtual work of liquid pressure exerting on the tank wall is also estimated analytically by assuming that the behavior of the liquid follows the velocity potential theory which includes the effect of sloshing. As a result of numerical studies, this solution is proved to be an effective and reasonable method for the seismic response analysis of a cylindrical liquid storage tank.

RINGS

82-671

Nonlinear Harmonic Oscillations of Gyroscopic Structural Systems and the Case of a Rotating Ring

A. Maewal
Dept. of Engrg. and Appl. Sci., Yale Univ., New Haven, CT, J. Appl. Mech., Trans. ASME, 48 (3), pp 627-633 (Sept 1981) 2 figs, 2 tables, 10 refs

Key Words: Shells, Rings, Gyroscopic excitation, Harmonic response

Two related problems are investigated in order to study via a simple example the influence of gyroscopic forces on nonlinear harmonic oscillations of rotationally symmetric shell structures. First, the amplitude frequency equations are calculated for circumferentially traveling waves in a circular ring rotating about its geometrical axis. The results show that in the range of rotational speeds considered the backward traveling waves exhibit hardening type of response, whereas for the forward traveling waves there is a transition from hardening to softening type of behavior as the rotational speed increases. The second part of the paper is devoted to an analysis of interaction between the two traveling waves which is expected at low angular speeds. The results, valid for arbitrary shells of revolution, reveal the existence of secondary bifurcation points on the branches corresponding to the traveling waves, and the response on the secondary branches is found to be close to standing waves which do not appear at all as solutions of the linear free-vibration problem for the rotating shell.

82-672

Sizing the Gap in Snap Rings

T.C. Nguyen
Pipe Hanger Div., ITT Grinnell Corp., Huntington

Beach, CA, Machine Des., 53 (18), pp 146-148 (Aug 6, 1981)

Key Words: Rings, Design techniques

A dimensionless equation and a graph is given for the determination of the angular gap in the design of snap rings that provide the required deflection under load.

PIPES AND TUBES

82-673

Experiments on Fluid Elastic Instability in Tube Banks Subjected to Liquid Cross Flow

S.S. Chen and J.A. Jendrzejczyk

Components Tech. Div., Argonne Natl. Lab., Argonne, IL 60439, J. Sound Vib., 78 (3), pp 355-381 (Oct 8, 1981) 16 figs, 14 tables, 33 refs

Key Words: Tube arrays, Fluid-induced excitation

An extensive test program was carried out to study fluid elastic instability of tube arrays subjected to cross flow. Critical flow velocities for 12 tube arrays with different spacing, mass ratio, damping, and detuning are established. From the experimental data, a stability map has been prepared; this is useful in design to avoid detrimental fluid elastic instability.

82-674

Large Amplitude Radial Oscillations of Inhomogeneous Tubes of Arbitrary Wall Thickness

A. Ertepinar and A. Gürkök

Dept. of Engrg. Sciences, Middle East Technical Univ., Ankara, Turkey, J. Sound Vib., 77 (4), pp 527-533 (Aug 22, 1981) 5 figs, 13 refs

Key Words: Tubes, Internal pressure, Oscillation

Finite radial oscillations of inhomogeneous tubes with arbitrary wall thickness subjected to a suddenly applied uniform internal pressure are investigated. The material is assumed to be of neo-Hookean type with radially varying material constant. The theory of finite elastic deformations is used in the formulation of the problem. The equation of motion written in an integrated form is solved partially to yield the frequency-pressure curves. As a special case, the problem of small, free vibrations of thick, inhomogeneous tubes is formulated.

82-675

Thermally Induced Acoustic Oscillations in a Pipe (1st Report: Oscillations Induced by Plane Heat Source in Air Current)

H. Madarame

Faculty of Engrg., Univ. of Tokyo, 7-3-1 Hongo Bunkyo-ku, Tokyo, Japan, Bull. JSME, 24 (195), pp 1626-1633 (Sept 1981) 20 figs, 5 refs

Key Words: Pipes (tubes), Thermal excitation, Acoustic response

Thermally induced acoustic oscillations in a pipe have been studied analytically and experimentally. Temperature distributions have been obtained near a heat source in a uniform flow with an acoustic field by solving heat-conduction equations. Experimental results agreed well with the analysis where the modified current velocity is used considering the boundary-layer around the heater. Some other characteristics of the oscillation have been discovered; for example, the growth rate of oscillation changes when turbulent transition occurs over a certain amplitude.

82-676

Vibrations of Three-Dimensional Pipe Systems with Acoustic Coupling

M. El-Raheb

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA 91103, J. Sound Vib., 78 (1), pp 39-67 (Sept 8, 1981) 10 figs, 2 tables, 26 refs

Key Words: Pipes (tubes), Fluid-induced excitation, Acoustic resonance

A general algorithm is developed for estimating the beam type dynamic response of three dimensional multiplane pipe systems consisting of elbows and straight segments with smooth interface. The transfer matrix approach is adopted in modeling the elastodynamics of each duct with allowance for distributed loads. The formulation includes the acoustic coupling of a plane wave and elbow curvature. Secondary loads from plane wave distortion are considered from a modal solution of the Helmholtz equation in an equivalent rigid waveguide with square cross section. The effect of path imperfection is introduced as a perturbation from the hypothetical perfectly straight pipe. The one dimensional plane wave assumption is valid for frequencies below half the first cut-off frequency. Wave asymmetry from elbow curvature produces substantial increase in response level near and above cut-off.

DUCTS

82-677

Transmission and Reflection of Higher Order Acoustic Modes in a Mitred Duct Bend

I.C. Shepherd and A. Cabelli

Div. of Mech. Engrg., Commonwealth Scientific and Industrial Res. Organization, Melbourne, Australia, J. Sound Vib., 77 (4), pp 495-511 (Aug 22, 1981) 7 figs, 2 tables, 24 refs

Key Words: Ducts, Sound propagation

A two dimensional finite element technique was used to investigate the characteristics of a 90° mitred bend for higher order modes. Experiments were used to corroborate the numerical results and good agreement was obtained between the two approaches for values of the wave number parameter extending to a little above the cut-on value of the second cross mode. The results are presented as modal contributions of the reflected and transmitted sounds when a propagating mode is incident on the bend.

82-678

Very Low Frequency Transmission Loss in Shallow Water

R.H. Ferris

MAR, Inc., Rockville, MD, Rept. No. MAR-TR-263, 55 pp (May 1981)

AD-A100 633

Key Words: Ducts, Underwater structures, Sound transmission loss

In this study, acoustic transmission loss is calculated at frequencies below cut-off for a shallow water duct. A highly idealized model, based on realistic estimates of the gross acoustic properties of the sea-bed, is used to calculate the energy distribution in range, frequency, and depth as functions of the major environmental parameters. Results show that values of loss, at frequencies below cut-off, are similar to those at the frequency of minimum loss above cut-off.

82-679

Active Adaptive Sound Control in a Duct: A Computer Simulation

J.C. Burgess

Acoustics Res. Dept., Bell Labs., Murray Hill, NJ 07974, J. Acoust. Soc. Amer., 70 (3), pp 715-726 (Sept 1981) 27 figs, 30 refs

Key Words: Ducts, Noise reduction, Digital simulation

Most active sound cancellation systems reported in the literature use open-loop control, depend on near-zero phase delay in control system elements, and require constant acoustic signal transit time from a signal pickup (microphone) to a control sound source (loudspeaker). The applicability of such systems can be significantly enhanced by using closed-loop control. This study concerns a digital computer simulation of adaptive closed-loop control for a specific application, sound cancellation in a duct. The method can be applied more widely, particularly to control systems that involve transport delay.

82-680

The Influence of Geometry on the Acoustic Characteristics of Duct Bends for Higher Order Modes

A. Cabelli and I.C. Shepherd

Div. of Mech. Engrg., Commonwealth Scientific and Industrial Res. Org., Melbourne, Australia, J. Sound Vib., 78 (1), pp 119-129 (Sept 8, 1981) 9 figs, 14 refs

Key Words: Ducts, Geometric effects, Acoustic response

A two-dimensional finite element technique, corroborated with experimental results, was used to explore the acoustic characteristics of 90° bends when cross modes propagate. The influence of changes in geometry on these characteristics was established over a range of inner and outer radii and the effects of including a turning vane were examined. The energy reflected was related where possible to the aerodynamic characteristics.

BUILDING COMPONENTS

82-681

Seismic Resistance Characteristics of Reinforced Concrete Beam-Supported Floor Slabs in Building Structures: Contribution of Floor Systems to Earthquake Resistance of Building Structural Frames

M. Nakashima, T. Huang, and L.-W. Lu

Fritz Engrg. Lab., Lehigh Univ., Bethlehem, PA, Rept. No. FEL-422.9, 353 pp (Apr 1981)

PB81-219172

Key Words: Structural members, Buildings, Floors, Reinforced concrete, Concretes, Beams, Seismic response

The in-plane seismic characteristics of reinforced concrete floor slabs which function as diaphragms are studied. The paper focuses on the floor slab system with edge beams, referred to as the beam-supported floor system. The investigation consists of four phases: experimental study, analytical study, parametric study, and dynamic response analysis.

82-682
Recent Progress in the Dynamic Plastic Behavior of Structures, Part III
N. Jones
Dept. of Mech. Engrg., The Univ. of Liverpool, P.O. Box 147, Liverpool L69 3BX, UK, Shock Vib. Dig., 13 (10), pp 3-16 (Oct 1981) 137 refs

Key Words: Beams, Plates, Shells, Transverse shear deformation effects, Rotatory inertia effects, Dynamic buckling, Reviews

This article surveys the literature on the dynamic plastic response of structures published since 1978. The review focuses on the behavior of such simple structural components as beams, plates, and shells subjected to large dynamic loads that cause extensive plastic flow of the material.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

82-683
Energy Input, Vibrational Level and Machinery Noise; Some Simple Relationships
E.J. Richards
Southampton Univ., UK, ASME Paper No. 81-DET-96

Key Words: Machinery noise, Discontinuity-containing media, Vibration excitation

Most excessive machine noise occurs as a result of sharp impacts or discontinuities in the machine system. This paper offers some simple laws which can be very helpful to machinery designers who do not wish to concern themselves with elaborate computations but who need basic diagnostic rules in their machine design work.

82-684
The Relative Variance of the Transmission Function of a Reverberation Room
J.L. Davy
Div. of Bldg. Res., Commonwealth Scientific and Indus. Res. Organization, Melbourne, Australia, J. Sound Vib., 77 (4), pp 455-479 (Aug 22, 1981) 5 figs, 9 refs

Key Words: Reverberation chambers, Sound transmission

The transmission function of a reverberation room is defined to be the square of the modulus of the ratio of the reverberant field sound pressure to the volume velocity of the sound source. The input impedance of a reverberation room is defined to be the ratio of the near field sound pressure to the volume velocity of the sound source. Lyon's formula for the relative variance of the transmission function is extended to cover the case when the transmission function is averaged over multiple source and receiver positions. This extended formula reduces easily to Lyon's formula for the relative variance of the real part of the input impedance and thus demonstrates the relationship which exists between the two formulae. The above formulae are derived under the assumption that the modal frequencies are randomly distributed. There is reasonable agreement between these formulae and the experimental results. The above formulae are extended to cover the case when the transmission function or the real part of the input impedance is averaged over a frequency band. The formulae derived in this paper are important for predicting the precision of sound power measurements in a reverberation room.

82-685
Scattering of Longitudinal and Transverse Waves by a Sub-Surface Crack
R.J. Brind and J.D. Achenbach
The Technological Inst., Northwestern Univ., Evanston, IL 60201, J. Sound Vib., 78 (4), pp 555-563 (Oct 22, 1981) 4 figs, 8 refs

Key Words: Elastic waves, Wave scattering, Cracked media

The scattering of time-harmonic longitudinal and transverse waves by a two-dimensional sub-surface crack, which is perpendicular to the free surface of an elastic half-space, is

investigated. The boundary-value problem for the scattered field is reduced to an uncoupled system of singular integral equations, which are solved numerically. These results are compared to the corresponding results for a surface-breaking crack. Some reciprocity relations, between the scattered far-fields generated by different incident waves, which provide a check on the analysis, are examined.

82-686
Acoustic Transients from Planar Axisymmetric Vibrators Using the Impulse Response Approach

P.R. Stepanishen
Dept. of Ocean Engrg., Univ. of Rhode Island, Kingston, RI 02891, J. Acoust. Soc. Amer., 70 (4), pp 1176-1181 (Oct 1981) 6 figs, 13 refs

Key Words: Sound waves, Vibrating structures

A generalized impulse response approach is developed to evaluate the transient pressures which result from a general time dependent axisymmetric velocity of a planar vibrator, e.g., a membrane, plate, or disk transducer. The approach, which is based on expressing the velocity distribution in terms of a set of radial orthonormal functions, leads to the pressure being expressed as a sum of convolution integrals which involve the time dependent coefficients of the orthonormal functions and generalized impulse responses. As a specific case of interest and importance, the generalized impulse response is developed for a radiator in which the orthonormal functions are zeroth-order Bessel functions of the first kind. Finally, some numerical results are presented to illustrate the effect of a nonuniform spatial velocity on the on-axis nearfield pressures of a pulsed radiator.

82-687
Normal-Mode Propagation in Deep-Ocean Sediment Channels

A.O. Williams, Jr.
Appl. Res. Labs., The Univ. of Texas at Austin, Austin, TX 78712 and Brown Univ., Providence, RI 02912, J. Acoust. Soc. Amer., 70 (3), pp 820-824 (Sept 1981) 2 figs, 6 refs

Key Words: Sound propagation, Underwater sound, Oceans

A normal-mode solution for ducted acoustic transmission in deep-ocean sediment channels just below the water-bottom interface presented here, yields eigenfunctions, the associated eigenvalue equation, and the minimum or cutoff acoustic frequency that allows trapping of any specified mode. Much of the acoustic energy propagating by any trapped mode travels through lossy bottom sediment. Accordingly, equations are derived for the attenuation coefficient of the nth mode. It is shown that sediment channels discriminate against long-range transmission by higher modes than the first, as well as at high acoustic frequencies and frequencies too near the cutoff value. Numerical examples are given for an "average" channel, at a frequency of 100 Hz.

82-688
Finite-Difference Solution to the Parabolic Wave Equation

D. Lee, G. Botseas, and J.S. Papadakis
Naval Underwater Systems Ctr., New London Lab., New London, CT 06320, J. Acoust. Soc. Amer., 70 (3), pp 795-800 (Sept 1981) 7 figs, 14 refs

Key Words: Sound propagation, Underwater sound, Finite difference technique

In this article an implicit finite-difference (IFD) scheme is introduced for solving underwater acoustic wave propagation problems. This scheme is applied to the parabolic wave equation model for the acoustic problem with a free surface and arbitrary bottom and bottom boundary conditions. The mathematical theory of the implicit finite-difference method as applied to the parabolic equation is developed, and a computer model to implement the IFD is introduced. Representative problems are presented to demonstrate the capability of the IFD model. Advantages and limitations of the IFD are discussed.

82-689
Under Ice Reflectivities at Frequencies Below 1 kHz

T.C. Yang and C.W. Votaw
Naval Res. Lab., Washington, DC 20375, J. Acoust. Soc. Amer., 70 (3), pp 841-851 (Sept 1981) 12 figs, 1 table, 15 refs

Key Words: Underwater sound, Ice, Oceans

An experiment measuring sonic reflectivities below 1 kHz was done beneath large smooth ice floes in the Arctic Ocean north of Ellesmere Island. Reflectivity data are presented here for grazing angles between 14° and 26°. The reflectivity is found strongly dependent on frequency as well as grazing angles. Theoretical discussions are given to interpret the data. The most significant finding of this report is that a smooth ice plate cannot be treated as totally reflective for frequencies between 200 Hz and 1 kHz, an assumption which has so

far been taken for granted in the literature. In fact, the reflection loss at smooth, flat ice could account for a substantial part of the transmission loss in Arctic oceans for this frequency range.

76 cm on an edge and 0.95-cm thick of steel and aluminum in the frequency range of 3-10 kHz. The signals were time limited to 200 μ s (0.6 to 2.0 wavelengths) by the arrival of the diffracted signal from the panel edges. Results are compared with theoretical values and indicate the method is capable of making measurements subject to ambient noise.

82-690

Propagation of Acoustic Wave along a Hollow Cylinder Immersed in a Liquid

A. Grabowska
Inst. of Fundamental Tech. Res., Polish Academy of Sciences, 00-049 Warszawa, ul. Swietokrzyska 21, Poland, Arch. Acoustics, 6 (1), pp 57-62 (1981) 3 figs, 4 refs

Key Words: Acoustic waves, Wave propagation, Cylindrical shells, Submerged structures

The problem of the propagation of a nonabsorbed, continuous, progressive and axially-symmetric acoustic wave along an infinite homogeneous and isotropic cylinder filled with air and immersed in an ideal liquid has been considered. The wave equations of displacement potentials have been solved. The characteristic equation has been derived for the preset boundary conditions and solved numerically for the selected data characteristic for the conditions of the biopsy performed in an ultrasonic field. It has been shown that a wave guided along a needle immersed in a liquid can propagate with the velocity only slightly smaller than the wave velocity of the surrounding liquid. The distributions of displacement, stresses and acoustic pressure of the propagating wave have been determined.

82-691

Modified Prony Method Approach to Echo-Reduction Measurements

D.H. Trivett and A.Z. Robinson
Underwater Sound Reference Detachment, Naval Res. Lab., P.O. Box 8337, Orlando, FL 32856, J. Acoust. Soc. Amer., 70 (4), pp 1166-1175 (Oct 1981) 14 figs, 5 refs

Key Words: Noise reduction, Noise measurement, Measurement techniques

A modified Prony method is presented for measuring the steady-state echo reduction of acoustic panels. The method extrapolates the steady-state amplitudes from the transient portion of the signal allowing time-limited measurements. The method is applied to measurements of square panels

82-692

Average Excess Attenuation During Sound Propagation from an Isotropic Source above Grassland

A. Soom and R.-R. Gu
Dept. of Mech. and Aerospace Engrg., State Univ. of New York at Buffalo, Buffalo, NY 14260, J. Acoust. Soc. Amer., 70 (4), pp 1129-1139 (Oct 1981) 17 figs, 1 table, 14 refs

Key Words: Sound attenuation, Isotropy

Measurements of sound attenuation from an isotropic source have been made over a meadow at propagation ranges between 15 to 300 m and for source and receiver heights within 3 m of the ground. Approximately 750 measurements were made at more than 70 source-receiver geometries under essentially constant ground conditions. The sound source was driven by a pseudo-random binary sequence signal giving a discrete spectrum in the 100- to 2500-Hz frequency range. The received signal was analyzed and averaged using Fast Fourier Transform techniques in narrow bands of 3 Hz. A separate measurement of the free-field source levels allowed excess attenuation to be relatively unambiguously calculated from the measured data. The surface used in the tests appears to have a boundary impedance different from grasslands studied by previous investigators. The effects of propagation range, source height, receiver height, and vector wind in determining excess attenuation are presented in detail. It is evident from the data that the theory of a simple source radiating into a quiescent, isothermal medium above an impedance plane often cannot be used to accurately predict average attenuation to distances much beyond 50 m from the source. Finally, it is shown that the method of averaging propagation data can significantly alter the apparent results.

82-693

Scattering of Sound Waves at a Periodic, Pressure-Release Surface: An Exact Solution

R.L. Holford
Bell Labs., Whippany, NJ 07981, J. Acc st. Soc. Amer., 70 (4), pp 1116-1128 (Oct 1981) figs, 33 refs

Key Words: Sound waves, Acoustic scattering, Oceans

It has been demonstrated that the problem of plane-wave scattering from a traveling ocean wave can be reduced to that of plane-wave scattering from a stationary, periodic, pressure-release surface. An exact method of solution to the latter problem is presented herein. The important characteristic of a periodic surface is that it produces strong, directional scattering when its period is comparable with the wavelength of the incident radiation, and the method provides an efficient scheme for numerical evaluation of the scattering amplitudes in case of a smooth profile of arbitrary shape. A review of previously reported "exact" solutions is given and it is shown that they fail for rather fundamental reasons which do not appear to be generally understood or appreciated.

82-694

Scattering of Sound Waves at the Ocean Surface: A Diffraction Theory

R.L. Holford
Bell Labs., Whippany, NJ 07981, J. Acoust. Soc. Amer., 70 (4), pp 1103-1115 (Oct 1981) 3 figs, 1 table, 26 refs

Key Words: Sound waves, Acoustic scattering, Oceans

Previous treatments of the scattering of sound at a rough ocean surface have dealt with cases where the surface irregularities are much larger or much smaller than the acoustic wavelength. This paper provides an attack on the important practical problem of cases where the surface roughness and acoustic wavelength are of comparable magnitude. In this approach, a complex ocean surface is considered to be decomposed into its periodic components or traveling waves, each of which acts as a moving diffraction grating that scatters the incident energy into certain characteristic directions (the diffraction orders) with associated Doppler shifts which are harmonics of the surface-wave frequency.

82-695

Acoustic Propagation over Ground Having Inhomogeneous Surface Impedance

J. Durnin and H.L. Bertoni
Dept. of Electrical Engrg. and Computer Sci., Polytechnic Inst. of New York, Brooklyn, NY 11201, J. Acoust. Soc. Amer., 70 (3), pp 852-859 (Sept 1981) 7 figs, 10 refs

Key Words: Sound propagation, Sound attenuation

Previously it was found that when an acoustic source is located above a porous ground plane of infinite lateral extent, the acoustic fields contain both surface wave and ground wave components. Because of these components the acoustic fields exhibit attenuation differing from the 6 dB per doubling of distance found for propagation over a hard surface. In this paper we consider the excess attenuation that occurs in the mixed path case when a portion of the ground plane is acoustically hard and the rest is porous. Expressions are derived for the attenuation when source and receiver are at ground level and on opposite sides of the boundary line between the hard and porous surfaces. Two different approaches were used to approximate the acoustic fields, and were found to give good numerical agreement. The theoretical results were also found to agree with measurements made at 1 kHz over a concrete-grass path.

82-696

Analysis of a Random Repeated Impact Process

L.A. Wood and K.P. Byrne
Engrg. Dept., General Motors - Holden's Limited, Port Melbourne, Victoria 3207, Australia, J. Sound Vib., 78 (3), pp 329-345 (Oct 8, 1981) 14 figs, 14 refs

Key Words: Random excitation, Impact noise

A simple random repeated impact process similar to the classical random walk process is analyzed. The process, which consists of a ball bouncing on a randomly vibrating surface, is analogous to loss-of-contact situations which can occur in linkages and vibrating tools. It also has relevance to rolling contact where the rolling element may separate from the surface and sustain repeated impacts. This information may then be used to predict the magnitudes of the impacts and the times between them.

82-697

Diffraction by a Hard-Soft Barrier

R.P. Kendig
Cambridge Acoustical Associates, Inc., 54 Ridge Ave. Ext., Cambridge, MA 02140, J. Acoust. Soc. Amer., 70 (4), pp 1156-1165 (Oct 1981) 15 figs, 18 refs

Key Words: Noise barriers, Acoustic scattering

An analytical solution for the diffraction by a half-plane is given for a plane-wave incidence and a point source. One surface of the half-plane has a hard impedance (rigid) and the other has a soft impedance (pressure release). The solution is obtained by function theoretic methods and has a

simple form in marked contrast to those obtained by the Wiener-Hopf technique. A null in the diffracted field was shown to exist as a function of the source location. In general, the diffracted field tended to resemble that of a soft-soft half-plane in the half-space adjacent to the soft face and resembles that of a hard-hard half-plane in the other half-space.

82-698

Design Considerations for Highway Noise Barriers

M.A. Simpson

Bolt, Beranek and Newman Inc., Canoga Park, CA, S/V Sound Vib., pp 16-23 (June 1981) 14 figs, 9 refs

Key Words: Noise barriers, Traffic noise, Noise reduction

This article describes a recently developed handbook for the highway engineer to aid in the design of noise abatement barriers. Several technical studies which were performed in support of this handbook are also described, including a field evaluation of highway noise barriers, an analytical investigation of parallel barrier effects, and an investigation of sound absorbing materials applicable in the highway environment. The concept of barrier insertion loss is defined and suggested as a valid measure of the net benefit of constructing a noise barrier along a highway.

SHOCK EXCITATION

(Also see No. 746)

82-699

Transient Response of a Finite Crack in a Half Plane under Impact Load

S. Itou

Dept. of Mech. Engrg., Hachinohe Inst. of Tech., Hachinohe 031, Japan, J. Appl. Mech., Trans. ASME, 48 (3), pp 534-538 (Sept 1981) 4 figs, 1 table, 9 refs

Key Words: Half-plane, Cracked media, Transient response, Impact response

Analytical investigation of a half plane weakened by a finite crack is considered. The crack is placed perpendicularly to the stress-free boundary of the half plane. The surfaces of the crack are loaded by a uniform pressure with Heaviside-function time dependence. In the Laplace transform domain, Fourier transformations are utilized to reduce the problem to the solution of a pair of dual integral equations which are solved by using the series expansion method. The Laplace inversion of the dynamic stress-intensity factors is carried out numerically.

82-700

Time Domain Waveform Inversion of Short-Period P-Waves for Nuclear Explosion Source Time Functions

L.J. Ruff

Sierra Geophysics, Inc., Arcadia, CA, Rept. No. SGI-R-80-034, AFOSR-TR-81-0495, 43 pp (Jan 9, 1981)

AD-A101 123

Key Words: Underground explosions, Nuclear explosions

An estimation of source time parameters of underground nuclear explosions from the waveforms of short-period teleseismic P-waves are investigated. In the simplest consideration, and when the source yield is unconstrained, there are only three source parameters.

82-701

Shock Development Prior to Detonation in Shaped Layered Nonlinear Elastic Media with Stochastic Variability

A. Jeffrey

Appl. Math. Inst., Delaware Univ., Newark, DE, Rept. No. AFOSR-TR-80-1083, 3 pp (Aug 29, 1980)

AD-A100 900

Key Words: Shock waves, Layered materials

The objective of this work was to examine the way in which an acceleration wave propagates in a randomly layered nonlinear medium in which the material constants vary stochastically from layer to layer. Furthermore the problem, although formulated as a one-dimensional configuration, was modified to describe propagation in a bar in which there is a slowly changing cross-sectional area. Thus the analysis may be applied to formed charges which have an axis of symmetry and a slowly varying cross-section normal to that axis.

82-702

Moments Between Impacting Rigid Bodies

R.M. Brach

Dept. of Aerospace and Mech. Engrg., Univ. of Notre Dame, Notre Dame, IN 46556, J. Mech. Des., Trans. ASME, 103 (4), pp 812-817 (Oct 1981) 4 figs, 1 table, 4 refs

Key Words: Impact response, Rigid bodies

It appears that all current literature in mechanics omits the effect of the moment developed between colliding rigid bodies. In many practical applications in design work, a significant moment can exist during impact and the impulse of the moment must be included in the equations for the change of angular momentum of each body. The general equations of impulse and momentum are presented for two rigid bodies colliding in planar motion. These reduce to six linear equations in the six unknown final velocities. The effect of the moment impulse on the angular velocities is taken into account through the use of a moment coefficient of restitution. This coefficient can take on realistic values between minus and plus one. Several examples are worked. An expression for the moment coefficient is derived for a vertically falling block which rebounds with a non zero angular velocity. This angular velocity is related to nonuniformities in the surface impacted by the block.

82-703
Propagation of Surface SH Waves in Nonhomogeneous Media
P. Kiełczyński
Inst. of Electron Tech., Warszawa, Poland, J. Tech. Phys., 22 (1), pp 73-78 (1981) 6 figs, 12 refs

Key Words: Shock waves, Shock wave propagation

The possibility has been demonstrated of existence of surface SH waves in nonhomogeneous media and the properties of these waves have been studied. The modal structure has been found of these waves. The theo. .cal results obtained are corroborated by the studies on propagation of acousto-electronic waves in piezoelectric ceramics. In this case a layer of diminished stiffness is formed in ceramics as a result of compensation of the piezoelectric field. The theory of surface SH waves may also be instrumental in non-destructive tests for defining the form of inhomogeneity in the surface layers of inhomogeneous media.

82-704
Boundary Solutions to Regular Refraction of Plane Shock Waves in Ideal Gas
Z. Łegowski and E. Włodarczyk
J. Tech. Phys., 22 (1), pp 79-101 (1981) 11 figs, 7 refs

Key Words: Shock waves, Shock wave propagation

The paper presents a general and complete analysis of the problem of a regular refraction of the stationary shock wave on the contact discontinuity separating two arbitrary ideal gases. Special attention has been paid to the boundary solutions of the elementary theory of regular refraction, beyond which the occurrence is expected of different types of irregular refractions. The subject of studies have also been the possible transitions within the set of solutions to regular refraction in function of the initial parameters. A number of new results have been achieved, among other things, a type of regular-irregular transition not mentioned so far in the literature, in which two solutions with a reflected rarefaction wave are preserved up to the moment when the flow behind the incident-wave front becomes sonic.

VIBRATION EXCITATION

82-705
Quenching in a System of Van der Pol Oscillators with Non-Linear Coupling
Y.P. Singh
Dept. of Electrical Engrg., Indian Inst. of Tech., Kanpur, Kanpur, 208016, India, J. Sound Vib., 77 (4), pp 445-453 (Aug 22, 1981) 5 figs, 6 refs

Key Words: Oscillators, Van der Pol method, Perturbation theory, Harmonic excitation

A perturbation analysis for non-linearly coupled van der Pol oscillators with harmonic forcing is presented. The disappearance of one frequency and hence the existence of single frequency oscillation due to the quenching effect is thus analytically demonstrated. The analytical results are confirmed by digital computer simulation. The effects of varying the forcing amplitude from small negative values to certain positive values are shown in the simulation results.

82-706
Resonance through a Strictly Singular Perturbation
K. Ingolfsson
Math. Res. Ctr., Wisconsin Univ., Madison, WI, Rept.

No. MRC-TSR-2202, 17 pp (Apr 1981)
AD-A100 605

Key Words: Resonant response

As a consequence of the formal difficulties in explaining resonances as solutions of the general Schroedinger equation, the procedure developed here exploits some fairly general properties of a semigroup, appropriate for the decay. A feature, which in this context may be named as 'the paradox of resonance', was analyzed to some extent. By generalizing the time development one can, however, formulate the resonant state in a consistent way. Its definition will be interpreted along the lines of strictly singular perturbations.

82-707

An Approach to Investigate the Instability of the Multiple-Degree-of-Freedom Parametric Dynamic Systems

K. Takahashi
Dept. of Civil Engrg., Faculty of Engrg., Nagasaki Univ., Nagasaki, Japan, J. Sound Vib., 78 (4), pp 519-529 (Oct 22, 1981) 6 figs, 1 table, 12 refs

Key Words: Multidegree of freedom systems, Harmonic balance method, Flexural vibration, Torsional vibration, Beams

A new analytical approach to the investigation of the regions of instability of multiple-degree-of-freedom parametric dynamic systems is presented. Upon assuming a solution as a product of a characteristic component and a vector which has a periodic component, expanding this vector into a Fourier series and substituting it into the governing equations of motion, a system of homogeneous algebraic equations can be obtained by the harmonic balance method. Then the problem of the stability of the non-trivial solutions results in an eigenvalue problem of a non-symmetric matrix. Numerical results are presented for an undamped and damped Mathieu equation whose stability has been investigated by various methods of solution. The method has been applied to multiple-degree-of-freedom systems such as lateral bending-torsional vibration of a thin beam under parametric excitation and the parametric instability of a column under periodically varying axial loads.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 613, 615, 628)

82-708

Effective Dynamic Properties of Composite Viscoelastic Materials

R.L. Kligman, W.M. Madigosky, and J.R. Barlow
Dept. of the Navy, Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, J. Acoust. Soc. Amer., 70 (5), pp 1437-1444 (Nov 1981) 5 figs, 3 tables, 24 refs

Key Words: Composite structures, Viscoelastic properties, Damping coefficients

General expressions for the dilatation modulus and density of composite viscoelastic materials are derived within the framework of a theory that is an extension of the self-consistent field approach. The dynamic dependence of these parameters is found up to values of wave number in the host medium times void radius equal to two. For various void concentrations and damping constants, the effective modulus shows regions of high stiffness and resonant compliance. The effective density shows single-peaked behavior for various concentrations and damping constants. In the long wavelength limit the effective modulus and density agree with the results of other investigators.

FATIGUE

(Also see Nos. 571, 593)

82-709

Application of Crack-tip-strain Loop to Fatigue-crack Propagation

H. Shimada and Y. Furuya
Dept. of Metal Processing and Mech., Metallurgy, Faculty of Engrg., Tohoku Univ., Sendai, 980, Japan, Exptl. Mechanics, 21 (11), pp 423-428 (Nov 1981) 10 figs, 2 tables, 9 refs

Key Words: Fatigue life, Crack propagation

Cyclic strain at the tip zone of a fatigue crack was measured continuously by the fine-grating method.

ELASTICITY AND PLASTICITY

82-710

Elastodynamic Stress-Intensity Factors for a Crack Near a Free Surface

J.D. Achenbach and R.J. Brind

Dept. of Civil Engrg., Northwestern Univ., Evanston, IL, J. Appl. Mechanics, Trans. ASME, 48 (3), pp 539-542 (Sept 1981) 6 figs, 5 refs

Key Words: Half-space, Cracked media, Elastodynamic properties

Elastodynamic Mode I and Mode II stress-intensity factors are presented for a subsurface crack in an elastic half space. The plane of the crack is normal to the surface of the half space. The half space is subjected to normal and tangential time-harmonic surface tractions. Numerical results show the variation of K_I and K_{II} at both crack tips, with the dimensionless frequency and the ratio a/b, where a and b are the distances to the surface from the near and the far crack tips, respectively. The results are compared with corresponding results for a crack in an unbounded solid.

82-711

Fields Near a Rapidly Propagating Crack-Tip in an Elastic Perfectly-Plastic Material

J.D. Achenbach and V. Dunayevsky

Dept. of Civil Engrg., The Technological Inst., Northwestern Univ., Evanston, IL 60201, J. Mech. Phys. Solids, 29 (4), pp 283-303 (1981) 6 figs, 12 refs

Key Words: Crack propagation

Dynamic effects are investigated for the steady-state fields of stress and deformation in the immediate vicinity of a rapidly propagating crack-tip in an elastic perfectly-plastic material. Both the cases of antiplane strain and in-plane strain have been considered. The governing equations in the plastic regions are hyperbolic in nature. Simple wave solutions together with uniform fields provide explicit asymptotic expressions for the stresses and the strains in the near-tip regions. The dynamic solutions describe a region of plastic loading which completely surrounds the propagating crack-tip.

82-712

Transient Response of an Inhomogeneous Elastic Half Space to a Torsional Load

K. Watanabe

Dept. of Mech. Engrg. II, Tohoku Univ., Sendai 980, Japan, Bull. JSME, 24 (195), pp 1537-1542 (Sept 1981) 7 figs, 21 refs

Key Words: Transient response, Torsional excitation, Elastic properties, Half-space

Transient response of an inhomogeneous elastic half space to an impulsive torsional load is discussed. Numerical computations are carried out in detail and they show that the inhomogeneous effect on the response is more remarkable when material parameters increase with depth than when those decrease.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

82-713

Recursive Digital Filters for Real-Time Applications: Part 3: Band-Pass Filters (Rekursive Digitalfilter für Echtzeitanwendungen)

E. Schwieger

Inst. f. Physik, GKSS Forschungzentrum Geesthacht GmbH, Reaktorstrasse 1, 2054 Geesthacht, W. Germany, Technisches Messen, 48 (9), pp 313-319 (Sept 1981) 15 figs, 6 refs

(In German)

Key Words: Digital filters, Real time spectrum analyzers

The third part of this paper presents digital band-pass filters obtained from the transfer functions of Butterworth low-pass filters by use of the Constantinides transformation. Such a filter shows advantages compared to a band-pass filter which is realized as a cascade of a low-pass and high-pass filter. The amplitude and phase of these filters are calculated. In addition, the amplitude of one filter is determined experimentally with a digital signal analyzer. Test calculations and a practical application show the efficiency of the band-pass filters.

82-714

Digital and Analog Filters for Processing Impact Test Data

J.K. Reichert and J.P. Landolt

Defence and Civil Inst. of Environmental Medicine, Downsview, Ontario, Canada, SAE Paper No. 810813

Key Words: Impact tests, Digital filters, Analog filters, Data processing

A set of digital and analog low-pass filters, which meet specific data-processing criteria for impact testing, are de-

scribed. The design, implementation and performance of the filters are discussed. These digital filters exhibit finite-impulse- and linear-phase-shift response characteristics. They were designed using the Remez exchange algorithm. The active analog filters, which exhibit a near-linear, phase shift, Bessel response, were developed using commercially-available integrated circuits.

82-715

Oscilloscopes that Remember

P.C. Dale
Instruments Div., Gould, Inc., Cleveland, OH, Mach. Des., 53 (25), pp 89-94 (Nov 12, 1981)

Key Words: Oscilloscopes

The advantages of digital oscilloscopes over their analog counterparts are described. Their displays, for example, never fade. Digital scopes can also catch transients or hard-to-predict signals without generating reams of charts or graphs, making them particularly useful for mechanical measurements.

82-716

Model for a Piezoelectric Polymer Flexural Plate Hydrophone

D. Ricketts
Raytheon Co., Submarine Signal Div., Portsmouth, RI 02871, J. Acoust. Soc. Amer., 70 (4), pp 929-935 (Oct 1981) 7 figs, 11 refs

Key Words: Hydrophones, Piezoelectric transducers

A mathematical model of the piezoelectric polymer flexural plate hydrophone is presented, with application to sheets of polymer attached to air-backed rectangular flexural plates. Expressions are given for the low-frequency electroacoustic sensitivity, as well as for the evaluation of hydrophone mechanical behavior under hydrostatic loading. Numerical results are presented for the supported plate and for the special case of a supported beam. The analytic results reveal that the selection criterion for the substrate plate should be its strength-to-elastic modulus ratio, in order to maximize the product of hydrophone sensitivity and maximum operating pressure. The theoretical model is applied to a plastic flexural plate polymer hydrophone, which results in close agreement between the predicted and measured sensitivities.

82-717

Digital Recording of Vehicle Crash Data

P.G. Fouts, G.A. Griggs, and E.J. Holdren
Chrysler Corp., SAE Paper No. 810810

Key Words: Crash sensors, Collision research (automotive), Data processing

This paper discusses the development and implementation of a 16 channel data acquisition system for high "G" impact testing which includes a self-contained, on-board data acquisition unit, a programmer-exerciser and debriefing subsystems. The microprocessor controlled, on-board unit contains all signal conditioning, A/D conversion hardware and logic to store 4K 12 bit samples of data per channel. This unit will debrief into an oscilloscope, a desk-top computer or a large disk-based minicomputer system. Advantages over previous systems include the elimination of costly hardware (such as umbilical cables and recorders), and a reduction in pre-test preparation and data processing time.

82-718

Advanced Automotive Crash Recorder Design Development and Test Analysis

K. Klaber
Natl. Highway Traffic Safety Administration, SAE Paper No. 810809

Key Words: Crash sensors, Collision research (automotive)

Development and testing of an advanced automotive crash recorder system shall be described. The device is biaxial and solid-state and utilizes a special portable data retrieval accessory for data collection in the field. Reliability at low cost, accuracy, and ease of operation were major design goals. The product retains both precrash and postcrash acceleration/time history information.

82-719

A Microcomputer-Based On-Vehicle Data Acquisition System

R.G. Bowersock, J.F. Dupree, and D.T. Bock
Ford Motor Co., SAE Paper No. 810811

Key Words: Crash sensors, Collision research (automotive), Data processing

A microcomputer-based, multichannel data acquisition system has been developed to acquire high frequency transient information typified by, but not limited to, automotive vehicle crash test applications.

82-720

Piezoelectric Transducers with Ideal Time Limited Impulse Response

D. Hazony
Dept. of Elect. Engrg. and Applied Physics, Case Inst. of Tech., Case Western Reserve Univ., Cleveland OH 44118, J. Acoust. Soc. Amer., 70 (3), pp 661-663 (Sept 1981) 6 figs, 7 refs

Key Words: Transducers, Piezoelectric transducers, Pulse excitation

Of interest is the performance of piezoelectric transducers where, in addition to transmission line effects, reactive effects are also present. Hence an ideal time limited response is nearly impossible without severe electrical and mechanical damping. It will be seen that the problem has an ideal solution. A carefully designed linear network is inserted in the electrical circuit rendering the output time limited.

82-721

Get the Right Waveform Digitizer for Your R&D Needs

R. Johnson and W. Baunach
Tektronix Inc., Beaverton, OR, Indus. Res. Dev., 23 (10), pp 174, 175-179 (Oct 1981)

Key Words: Amplitude data, Data processing, Digital techniques

This article describes a waveform digitizer which converts the amplitude of a signal into digital values at various points in time, then stores these values in a memory device.

82-722

Qualification of a 94-Cubic Metre Reverberation Room under ANS S1.21

M.A. Lang and J.M. Rennie
Centre for Bldg. Studies, Concordia Univ., 1455 de Maisonneuve Blvd., West, Montreal, Quebec, Canada H3G 1M8, Noise Control Engrg., 17 (2), pp 64-70 (Sept-Oct 1981) 9 figs, 1 table, 13 refs

Key Words: Noise measurement, Test facilities, Reverberation chambers

The qualification of a reverberation chamber of lightweight construction for pure tone and broad band sound power measurement, in accordance with American National Standard S1.21 - 1972, is described. The room modifications required were a rotating diffuser, two stationary diffusers, low frequency panel absorbers and Helmholtz resonators. The effect of these modifications is documented and discussed in light of current theory and previous research.

82-723

A Comparison of Various Techniques for the Prediction of Mass-Loaded Mode Shapes and Natural Frequencies

F.B. Atkinson
School of Engrg., Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/GAE/AA-80D-1, 130 pp (Mar 1981)
AD-A100 820

Key Words: Modal analysis, Mode shapes, Natural frequencies

The purpose of this investigation was to compare the results obtained from three modal prediction techniques. The first technique was an algorithm developed by Whaley for lightly damped structures. Results using this algorithm were extracted from a thesis by Glenesk. The second method was the finite element method using NASTRAN. The final method was the recovery of unloaded mass and stiffness matrices from the general matrix-vector differential equation of modal analysis using modal data obtained from an unloaded test item.

82-724

Application of Faraday's Effect in Static and Dynamic Holographic Photoelasticity

Y.W. Qin
Dept. of Basic Sciences, Tianjin Univ., Tianjin, China, Exptl. Mechanics, 21 (10), pp 389-393 (Oct 1981) 7 figs, 9 refs

Key Words: Holographic techniques, Photoelastic analysis

The basic principle of applying Faraday's effect to achieve the separation of fringes in static and dynamic holographic photoelasticity, and a study and application of Faraday's light rotator are described in this paper. It is proposed that Faraday's light rotator be used for automating photoelastic instrumentation for measuring isoclinics and the decimal orders of isochromatic fringes.

DYNAMIC TESTS

82-725
The Data Acquisition System at the DCIEM Impact Studies Facility

T.J. Bowden, J.K. Reichert, and J.P. Landolt
Defence and Civil Inst. of Environmental Medicine, Downsview, Ontario, Canada, SAE Paper No. 810812

Key Words: Impact tests, Data processing, Digital techniques

A data acquisition system for impact testing which uses a set of 49 Datalab recorders is described. Each of these recorders converts an analog transient electrical signal into digital form at sampling rate up to 200 kHz and stores 4096 samples for subsequent transfer to a computer. Data processing and plotting of results, including resultants and severity indices, is completed within 40 minutes of a test. The system offers a speed and versatility far superior to alternative systems using analog FM magnetic tape recorders.

82-726
Vibration and Performance Testing with Small Digital Test Systems

R.G. Smiley
Anatrol Corp., Cincinnati, OH, SAE Paper No. 810693

Key Words: Vibration tests, Testing techniques, Digital techniques, Fourier analysis

Recent advances in electronics and technical advances in testing techniques have made the smaller Fourier Analyzer test systems much more attractive as a more portable, more flexible alternative to large, rack-mounted minicomputer-based test systems. This paper reviews numerous experimental tests performed in structural dynamics and operating performance by mechanical engineers in terms of their speed, data base size, calculation complexity, and transducer interface requirements in an attempt to clarify the position of the smaller test system in the mechanical engineering test profession.

82-727
Quantitative Ultrasonic Evaluation of Engineering Properties in Metals, Composites, and Ceramics

A. Vary
NASA Lewis Res. Ctr., Cleveland, OH, NASA Tech. Memo. 81530 (Prepared for the 1st Seminar on Advanced Ultrasonic Technology sponsored by the National Research Council of Canada - Longueuil, Quebec, June 9-10, 1980)

Key Words: Nondestructive tests, Ultrasonic techniques

This paper reviews ultrasonic technology from the perspective of nondestructive evaluation approaches to material strength prediction and property verification. Emergent advanced technology involving quantitative ultrasonic techniques for materials characterization is described. Ultrasonic methods are particularly useful in this area because they involve mechanical elastic waves that are strongly modulated by the same morphological factors that govern mechanical strength and dynamic failure processes. It is emphasized that the technology is in its infancy and that much effort is still required before all the available techniques can be transferred from laboratory to industrial environments.

82-728
Comparison of Transient Response Test Procedures for Motor Vehicles

M.K. Verma and W.L. Shepard
Engrg. Mech. Dept., General Motors Res. Labs., Warren, MI, SAE Paper No. 810807

Key Words: Transient response, Testing techniques, Motor vehicles

This paper presents a brief description of several test procedures for measuring the transient lateral response characteristics of motor vehicles. The random steering and the step response techniques are studied in detail by being used to evaluate different vehicles. The correlation between the numerics obtained from these two test procedures is investigated.

SCALING AND MODELING

82-729
Scale Models in Control Systems Engineering

P.E. Wellstead
Control Systems Centre, Inst. of Sci. and Tech., Univ. of Manchester, P.O. Box 88, Manchester

M60 10D, UK, Trans. Inst. Meas. and Control, 2 (3), pp 137-155 (July-Sept 1980) 25 figs, 8 refs

Key Words: Scaling, Model testing

The article describes the role played by scale models in dynamical systems studies and control engineering. The paper describes how such a range of models is used to illustrate the essential features and methods of mathematical modeling, system identification, analysis and control.

DIAGNOSTICS

82-730

Detection of a Transverse Crack in a Turbine Shaft -- The Oak Creek Experience

J.J. Kottke and R.H. Menning

Wisconsin Elect. Power Co., Milwaukee, WI, ASME Paper No. 81-JPGC-Pwr-19

Key Words: Diagnostic techniques, Turbine components, Shafts, Signature analysis

Abnormal transient vibration levels detected by turbine supervisory instrumentation and investigation with signature analysis technique led to the conclusion that the low pressure turbine shaft contained a transverse crack. After the evaluation of data collected under various conditions, it was found that the vibration occurred only after a reduction in steam temperature.

82-731

Detection and Early Diagnosis of Potential Failures of Rotating Machinery

R.F. Bosmans

Bently Nevada Corp., Minden, NV, ASME Paper No. 81-JPGC-Pwr-28

Key Words: Diagnostic techniques, Rotating machinery

This paper outlines the measurement parameters to be utilized, the instrumentation requirements, a means of classifying malfunction types, and finally the corrective action required to insure proper operation of rotating machinery. All of the aforementioned subjects are the ingredients necessary to prepare operating personnel for early diagnosis of potential failures of rotating machinery.

82-732

Proposed Dynamic Phase Difference Method for the Detection of Tile Debonding from the Space Shuttle Orbiter

A.J. Zuckerwar and D.R. Sprinkle

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83140, 14 pp (June 1981)

N81-26172

Key Words: Diagnostic techniques, Phase data, Beat frequency, Tiles, Spacecraft

A noncontacting, semi-global, dynamic technique was developed for detecting loose tiles on the space shuttle orbiter.

BALANCING

82-733

Balanced Wheels: More Important Than Ever

D.J. Holt

Society of Automotive Engineers, Inc., Auto. Engr. (SAE), 89 (7), pp 43-47 (1981) 9 figs

Key Words: Balancing techniques, Dynamic balancing, Wheels

Static and dynamic wheel balancing techniques are reviewed.

82-734

Dynamic In-Place Balancing of Rotating Machinery

J.W. Miller

Preventive Maintenance Co., Inc., Schiller Park, IL, Plant Engrg., 35 (20), pp 75-77 (Oct 1, 1981) 3 figs

Key Words: Balancing techniques, Single-plane balancing, Rotating machinery

The concept of unbalance is discussed and an outline of single-plane procedures for in-plane balancing is presented.

82-735

A New Concept for Force Balancing Machines for Planar Linkages. Part 2: Application to Four-Bar Linkage and Experiment

S.J. Tricamo and G.G. Lowen

Dept. of Mech. Engrg., Stevens Inst. of Tech., Hoboken, NJ 07030, J. Mech. Des., Trans. ASME, 103 (4), pp 784-792 (Oct 1981) 10 figs, 2 tables, 2 refs

Key Words: Balancing machines, Linkages, Minimax technique, Least squares method

This paper represents Part 2 of a two-part investigation on balancing devices for planar linkages. The theory shown in Part 1 is applied to the development of an experimental machine for theoretically fully forced balanced four-bar linkages. Minimax and least squares approaches were formulated and adapted for solution by an existing augmented Lagrangian penalty function code. Both methods reduced the magnitudes of the actual shaking force components by more than fifty percent.

MONITORING

82-736

Acoustic Emission Monitoring of Steam Turbines

A.F. Armor, L.J. Graham, and R.L. Frank

Elect. Power Res. Inst., Palo Alto, CA, ASME Paper No. 81-JPGC-Pwr-16

Key Words: Monitoring techniques, Acoustic emission, Steam turbines

This paper describes the form of acoustic emission signals from turbines and discusses the material characterization tests in light of this data. In addition to shaft cracking detection, acoustic emission monitoring appears to be a viable technique for detecting incipient bearing failures, for the detection and location of blade rubbing and for early warning of an out-of-balance condition.

82-737

Monitor Your Turbine/Generator to Assure Operational Integrity

P.S. Baur

POWER, Highstown, NJ, POWER, 25 (5), pp 39-46 (May 1981) 10 figs

Key Words: Monitoring techniques, Rotating machinery

The article presents an in-depth view of what specific problems are causing prime-mover and end-mover failures, and how industry is responding to new challenges in plant reliability with better monitoring capability.

82-738

Early Detection of Cross-Sectional Rotor Cracks by Turbine Shaft Vibration Monitoring Techniques

H. Ziebarth and R.J. Baumgartner

Kraftwerk Union AG, Muelheim, W. Germany, ASME Paper No. 81-JPGC-Pwr-26

Key Words: Monitoring techniques, Crack detection, Turbine components, Shafts

A cross-sectional crack greatly influences the dynamic behavior of a turbine rotor. The reason for this is the angle-dependent alternations of the rotor stiffness, which act as external excitation on the system.

82-739

Generator Shaft Torsional Phenomena - Stressing of Large Turbines at Shaft Couplings and LP Blade Roots and Governing Following Electrical System Disturbances

T.J. Hammons

Elect. and Computer Engrg. Dept., McMaster Univ., Hamilton, Ontario, Canada, Inst. of Engineers, Australia, Trans., Civil Engrg., 6 (2), pp 104-117 (July 1981) 9 figs, 3 tables, 17 refs

Key Words: Shafts, Torsional response, Fatigue life, Monitoring techniques

Turbine-generator shaft torsional phenomena is reviewed. Transient torque at shaft couplings and LP turbine final-stage blade roots following severe disturbances on the electrical supply is examined. Fatigue life expenditure of shafts and fatigue monitors are also discussed, as is shaft torsional phenomena in governing large generators following worst-case system events.

ANALYSIS AND DESIGN

ANALOGS AND ANALOG COMPUTATION

82-740

Eigensolution Using Lagrangian Interpolation

M.S. Iyer

Dept. of Civil Engrg., Univ. of Zambia, Lasaka, Zambia, Intl. J. Numer. Methods Engrg., 17 (10), pp 1443-1453 (Oct 1981) 1 fig, 1 table, 18 refs

Key Words: Eigenvalue problems, Lagrange equations

A computationally efficient and accurate solution technique for large-order eigenvalue problems with small to medium bandwidth is presented. The algorithm -- called the Sub-Polynomial Iteration (SPI) method -- solves for the eigenvalues and corresponding eigenvectors directly without any transformation to the standard form. The method is an efficient combination of several separate techniques including Sturm sequence, Lagrangian polynomial interpolation, inverse iteration with shift and Gram-Schmidt orthogonalization. Computer run times for a set of sample solutions indicate the efficiency of the SPI method.

ANALYTICAL METHODS

82-741

A Generalized Theory of Cell-to-Cell Mapping for Nonlinear Dynamical Systems

C.S. Hsu

Dept. of Mech. Engrg., Univ. of California, Berkeley, CA, J. Appl. Mech., Trans. ASME, 48 (3), pp 634-642 (Sept 1981) 7 refs

Key Words: Cell-to-cell mapping, Dynamic systems

In this paper the theory is generalized by allowing the mapping of a cell to have multiple image cells with appropriate individual mapping probabilities. This generalized theory is able to deal with very fine and complicated global behavior patterns, if they exist, in a more attractive way without having to utilize extremely small cell sizes.

82-742

Higher Approximation of Steady Oscillations in Nonlinear Systems with Single Degree of Freedom (Suggested Multi-Harmonic Balance Method)

H. Tamura, Y. Tsuda, and A. Sueoka

Kyushu Univ., Hakozaki, Higashi-ku, Fukuoka-City, Fukuoka-Prefecture, Japan, Bull. JSME, 24 (195), pp 1616-1625 (Sept 1981) 3 figs, 16 refs

Key Words: Nonlinear systems, Single degree of freedom systems, Harmonic balance method, Periodic response

In order to obtain the higher order approximate solutions for steady oscillations of a nonlinear system, a so-called multi-harmonic balance method is suggested for computing a number of harmonic components simultaneously. The formalization of the computation in the successive approximation is devised by applying the complex Fourier series and the general and detailed procedure is indicated clearly.

MODELING TECHNIQUES

(Also see No. 679)

82-743

Application of Structural Optimization Technique to Reduce the External Vibrations of a Gas-Turbine Engine

H. Bedrossian and R. Phoenix

AVCO Lycoming Div., Stratford, CT, ASME Paper No. 81-DET-143

Key Words: Gas turbine engines, Finite element technique, Mathematical models, NASTRAN (computer programs), Natural frequencies, Mode shapes

The development of a structural and dynamic finite element model of a complete gas-turbine engine was achieved. A normal modes analysis identified the natural frequencies and associated mode shapes for the engine structure within its operating range.

82-744

A Correct Model Building in the Dynamics of Discrete Systems (Zur korrekten Modellbildung in der Dynamik diskreter Systeme)

H. Troger and K. Zeman

Institut f. Mechanik Technische Universität Wien Karlsplatz 13, A-1040 Wien, Austria, Ing. Arch., 51 (1/2), pp 31-43 (1981) 14 figs, 13 refs

(In German)

Key Words: Mathematical models

In order to obtain a correct model of a linear, autonomous, dynamical system with the right number of parameters the theory of bifurcation diagrams of matrices is used. As examples two double pendula with a follower force respectively with dead loading are considered.

STATISTICAL METHODS

82-745

Stochastic Models for Dependent Load Processes

Y.K. Wen and H.T. Pearce

Dept. of Civil Engrg., Univ. of Illinois at Urbana-Champaign, Rept. No. UILU-ENG-81-2002, 81 pp (Mar 1981)

PB81-219735

Key Words: Stochastic processes, Structural response, Pulse excitation

Stochastic models for dependent loads and load effects are developed. The effects of stochastic dependencies on load combination and structural reliability are investigated in the context of summation of pulse processes in which occurrence time, intensity and duration are allowed to be correlated within each process and between processes. Approximate analytical solutions based on a load coincidence method are obtained and verified by Monte-Carlo simulations. It is found that while within load positive correlations may generally have only moderate effect on the combined load probability, between-load dependencies may be dominant factors and significantly increase the probability of threshold level being exceeded by the combined load.

COMPUTER PROGRAMS

82-746

Nuclear Blast Program for Mini-Calculators

R.P. Patrick

Aircraft Engrg. Div., Strategic Air Command, Offutt AFB, NE, Rept. No. SAC/LGME-ER-S-111, 16 pp (Mar 9, 1981)

AD-A101 091

Key Words: Computer programs, Nuclear explosions, Shock waves

A program has been written for the HP-97 (HP-67) mini-computer to solve the blast wave from a nuclear detonation.

GENERAL TOPICS

TUTORIALS AND REVIEWS

(See No. 682)

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CALENDAR

APRIL 1982

14-16 Fatigue Conference and Exposition [SAE] Dearborn, MI *(SAE Hqs.)*

18-22 Gas Turbine Conference and Products Show [ASME] London, England *(ASME Hqs.)*

19-21 77th Annual Meeting of the Seismological Society of America [SSA] Anaheim, CA *(SSA, 2620 Telegraph Ave., Berkeley, CA 94704 - (415) 848-0954)*

20-22 Mechanical Failures Prevention Group 35th Symposium [National Bureau of Standards] Gaithersburg, MD *(Dr. James G. Early, National Bureau of Standards, Bldg. 223/Room A-113, Washington, DC 20234 - (301) 921-2976)*

20-23 Institute of Environmental Sciences' 28th Annual Technical Meeting [IES] Atlanta, GA *(IES, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)*

22-23 13th Annual Pittsburgh Conference on Modeling and Simulation [School of Engineering, Univ. of Pittsburgh] Pittsburgh, PA *(William G. Vogt or Marlin H. Mickle, Modeling and Simulation Conf., 348 Benedum Engrg. Hall, Univ. of Pittsburgh, Pittsburgh, PA 15261)*

26-30 Acoustical Society of America, Spring Meeting [ASA] Chicago, IL *(ASA Hqs.)*

MAY 1982

12-14 Pan American Congress on Productivity [SAE] Mexico City *(SAE Hqs.)*

24-26 Commuter Aircraft and Airline Operations Meeting [SAE] Savannah, GA *(SAE Hqs.)*

JUNE 1982

7-11 Passenger Car Meeting [SAE] Dearborn, MI *(SAE Hqs.)*

JULY 1982

1-3 2nd Intl. Conf. on Applied Modeling and Simulation [IASTED] Paris, France *(AMSE, 16 avenue de Grange Blanche, 69160 Tassin la Demi Lune, France)*

13-15 'Environmental Engineering Today' Symposium and Exhibition [SEE] London, England *(SEECO 82 Organisers, Owles Hall, Buntingford, Herts. SG9 9PL, England - Tel: Royston (0763) 71209)*

19-21 12th Intersociety Conference on Environmental Systems [SAE] San Diego, CA *(SAE Hqs.)*

AUGUST 1982

16-19 West Coast International Meeting [SAE] San Francisco, CA *(SAE Hqs.)*

SEPTEMBER 1982

12-15 1982 Design Automation Conference [ASME] Washington, DC *(Prof. Kenneth M. Ragsdell, Purdue Univ., School of Mechanical Engrg., West Lafayette, IN 47907 - (317) 494-8607)*

13-16 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI *(SAE Hqs.)*

OCTOBER 1982

4-6 Convergence '82 [SAE] Dearborn, MI *(SAE Hqs.)*

4-7 Symp. on Advances and Trends in Structural and Solid Mechanics [George Washington Univ. and NASA Langley Res. Ctr.] Washington, DC *(Prof. Ahmed K. Noor, Mail Stop 246, GWU-NASA Langley Res. Ctr., Hampton, VA 23665 - (804) 827-2897)*

12-15 Stapp Car Crash Conference [SAE] Ann Arbor, MI *(SAE Hqs.)*

25-28 Aerospace Congress & Exposition [SAE] Anaheim, CA *(SAE Hqs.)*

26-28 53rd Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, DC] Danvers, MA *(Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, DC 20375)*

NOVEMBER 1982

8-10 Intl. Modal Analysis Conference [Union College] Orlando, FL *(Prof. Raymond Eisenstadt, Union College, Graduate and Continuing Studies, Wells House, 1 Union Ave., Schenectady, NY 12308 - (518) 370-6288)*

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210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
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Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

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- volume, number or issue, and pages for journals; publisher for books
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A sample reference list is given below.

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